The Psychophysiological Correlates of Empathy in Couple Interactions

by

John O' Mara, BA (Maths), BAI (Hons, Engineering), BA (Hons, Psych)

Submitted in partial fulfilment of the requirements

for the degree of Doctor of Philosophy (Clinical Psychology)

University of Tasmania

May, 2001

I certify that this thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution, and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signed

Date 8/8/01

Abstract

This thesis examines the relationships between physiological linkage and empathy in dyadic couple interactions. Physiological linkage occurs when the dynamic changes in the physiology of one person are followed by equivalent changes in the physiology of another.

The current research emerged from the innovative work of Levenson and Gottman (1983) who used bivariate time-series analysis techniques to examine physiological linkage in neutral and conflictual couple interactions. They found that physiological linkage was negatively correlated (r = -.31) with marital satisfaction during conflict interactions only, and predicted 60% of the variance in marital satisfaction. In a later study, Levenson and Ruef (1992) found that strangers rating the affect of a target spouse were physiologically linked for 28% to 33% of physiological variables, and that physiological linkage was significantly correlated with rating accuracy for negative affect only. Levenson and Ruef interpreted physiological linkage as representing a physiological substrate of empathy.

For the current research a three stage model of empathy was developed to provide a conceptualisation of the empathic process and guide the selection of measures for empathy. To the neutral and conflict interactions used in the earlier studies a third positive interaction was added. Turn-taking, rather than naturalistic interactions, were used to aid empathic listening. It was hypothesised that, when non distressed couples listen empathically to each other: (a) physiological linkage would occur where the physiology of the listener follows the physiology of the speaker; (b) physiological linkage would be predictive of perspective-taking (i.e., empathic listening) and, (c) marital satisfaction; and (d) perspective-taking would be correlated with marital satisfaction.

Results supported these hypotheses: (a) Significant physiological linkage occurred for 38% of physiological measures during neutral discussions, 42% during happy, and 41% during discussions of conflict. The direction of linkage was that the listener consistently followed the speaker; (b) physiological linkage predicted up to 55% of the variance in perspective taking ability; (c) and up to 51% of the variance in marital satisfaction, and (d) perspective-taking was positively correlated with marital satisfaction for six of nine comparisons (*p*s $< .01$).

The results indicated that physiological linkage occurs when spouses listen empathically and extended the findings of Levenson and Gottman (1983) to the expression of neutral and positive affect. Support was also provided for the proposed model of empathy and Levenson and Ruef's (1992) contention that physiological linkage signifies the feeling component of empathy.

Acknowledgments

Thanks go to my supervisor Iain Montgomery for helping to keep me on track and focussed on the pragmatics of writing up the thesis when I became less outcome oriented. Also thanks to George Wilson for many hours of valuable discussions on psychophysiology and the subtleties of the MacLab recording system. Similarly, thanks to John Davidson for struggling with me to sort out the statistical analysis. Thanks to Brian Rieusset for designing circuitry to synchronise the video and MacLab systems, and for teaching me how to use the video lab. Thanks to Dave Chatterton and John Wanless for their on going technical support, assistance with computer problems, and physiological wiring arrangements. Particular thanks to Vlasti Broucek for coming to the rescue with the program to reduce data processing time. Thanks to Sue Ross for her interest in my life beyond research, and to Pam Titherly and Heather Williams who helped me navigate the bureaucratic side of university life.

But first and definitely not last, thanks to my poor suffering family, without whose support and understanding I would have completed this thesis two years ago and been in therapy; but with it, I have achieved some balance over the past ten long years. I look forward to spending more time with my partner Michele, and sons Ciaran and Aidan.

Table of Contents

Chapter 1

Introduction

Chapter 1

Introduction

This thesis addresses the issue of empathy in dyadic couple interactions and whether physiological linkage (the physiological response of one person following the physiological response of another) signifies the feeling component of empathy. That is, if the presence of physiological linkage indicates that one person has shared emotions with another, and is 'feeling along with' the other empathically.

In the literature there is a continuing debate regarding the definition of empathy and whether it should be conceptualised as a unidimensional or multidimensional construct. There is also debate concerning how particular constructs of empathy may be interrelated and how they may be operationalised for experimental purposes (e.g., Duan & Hill, 1996). These issues have created a high level of complexity and some confusion in the empathy literature where theories of the overall empathic process are scarce (an exception is Davis & Oathout, 1987). As a result it is difficult to determine, in individual studies, which components of empathy are actually being measured, the theoretical basis of these measurements, and how the results contribute to an understanding of the empathic process.

For the current research it was identified that a basic model of the empathic process would (a) assist in developing a conceptual understanding of the extensive literature pertaining to empathy, (b) provide a conceptual framework to organise and categorise studies, (c) assist in the formulation of research questions, and (d) assist in identifying how they may be operationalised experimentally. Consequently, a generic model of empathy was developed that aided the conceptualisation and measurement of the empathic process. The theoretical basis of the model is outlined in chapter 2.

The early research on the psychophysiology of dyadic interactions is reviewed in chapter 3. This early research established the presence of shared physiology during dyadic interactions, and provided some support that empathy may mediate the shared physiology that occurred during positive interactions (e.g., DiMascio, Boyd, & Greenblatt, 1957; Robinson, Herman, & Kaplan, 1982). However, a range of methodological and data analysis issues limited the inferences and conclusions that could be drawn from this research for shared physiology (e.g., Levenson & Ruef, 1992; Wagner & Calam, 1988).

Most of the limitations evident in the earlier research were overcome by the introduction of new methodology and bivariate time-series analysis techniques to explore dyadic interactions (Levenson & Gottman, 1983). These developments are introduced in chapter 4. Key studies, using this new methodology, are reviewed in detail and the inferences that may be drawn from them are discussed. An outline of the research question completes chapter 4.

As the methodology used in the current research was new at the University of Tasmania a range of methodological issues required resolution. These methodological issues and their solutions are described in chapter 5. The rationale for the current research, the specific hypotheses to be tested, the methodology used, and the results for this research are presented in chapter 6.

In chapter 7 the results of this investigation are discussed in relation to the support provided for the hypotheses and the proposed three stage model of empathy. The limitations of the current research and implications for future research are also presented in this chapter.

Chapter 2

The Three Stage Model of Empathy

Chapter 2

The Three Stage Model of Empathy

Background

Empathy is a complex and elusive phenomenon that has generated a diverse body of literature. Some of the complexity is due to researchers being unable to agree on a definition of empathy (e.g., Chlopan, McCain, Carbonell, & Hagen, 1985; Hickson, 1985) and to differentiate between empathy and the closely related concept of sympathy (e.g., Gruen & Mendelsohn, 1986; Wispe, 1986). Further difficulties arise as to how empathy occurs and whether empathy is best conceptualised as a unidimensional or a multidimensional construct (e.g., Davis, 1983a, 1983b; Deutsch & Madle, 1975). Empathy also remains elusive because of the difficulty of operationalising any given construct of empathy for research purposes (e.g., Duan & Hill, 1996).

The diversity in the literature arises, in part, from the increasing recognition of how fundamental empathy is in human development (Ungerer, Dolby, Waters, Barnett, Kelk, & Lewin, 1990), interpersonal communication (Borke, 1971; Bolton, 1987), therapy (Egan, 1994; Rogers, 1980), leadership style (Woodall & Kogler-Hill, 1982), prosocial behaviour and altruism (Batson, O'Quin, Fultz, Vanderplas, & Isen, 1983; Batson, 1991; Eisenberg et al., 1989; Eisenberg & Miller, 1987; Hoffman, 1976), and moral development and moral judgment (Hoffman, 1990; Hogan, 1969, 1973).

Hickson (1985) considered that the diversity of definitions and approaches to the study of empathy has led to confusion and concludes in her review that "...the present literature suggests conflicting definitions, ambiguous criteria for measuring the empathic response, and the lack of a comprehensive theoretical approach in studying the phenomenon. The question raised by the present inquiry is whether anyone has been able to measure empathy successfully" (p. 93).

In this chapter a multidimensional model of empathy is introduced which addresses several of these issues. The model incorporates three elements of empathy, which have been consistently identified in the literature. These are *knowing* what another is feeling, *feeling* to some degree what another is feeling, and *responding compassionately* to another. These three aspects of empathy are integrated into a three stage model to provide a conceptualisation of the empathic process. The rationale for the overall model is described and the research support is outlined for the elements included in the model. The perceived advantages of the model are briefly described followed by a discussion of the role of the model in the current research.

Rationale for a Three Stage Model of Empathy

Two distinct types of empathy have been consistently identified in the literature. Mehrabian and Epstein (1972) describe the first as a cognitive role-taking ability that enables one to understand accurately and predict another's thoughts, feelings, and actions. The second follows Stotland's (1969) approach where empathy is defined as "...an observer's reacting emotionally because he perceives that another is experiencing or is about to experience an emotion" (p. 272). Hallenback (1981) also considers that empathy comprises both cognitive and affective components but that the affective component of empathy is somewhat ignored in the literature and contends that "...cognitive understanding of social and emotional situations is necessary but not sufficient for empathy to occur" (p. 226). Similarly, Gladstein

(1984) in his historical review identifies that empathy is typically defined "...as either (1) a cognitive process of understanding what another person is thinking or feeling, or (2) an affective process of taking on the feelings of another person" (p. 38).

Davis (1983a) noted that the historical differentiation between the cognitive and emotional components of empathy was largely maintained as two separate research traditions in the literature. He suggested that they be integrated in a multidimensional theory of empathy where the relationships between the various components of empathy and specific outcome variables be systematically explored (Davis, 1983b). In a study of dispositional empathy on romantic relationship behaviours Davis and Oathout (1987) introduced a four stage model of the empathic process. The first stage included three factors of dispositional empathy - perspective-taking (non emotional or cognitive), empathic concern (the tendency to feel warmth and compassion), and personal distress (feelings of anxiety or unease). These factors were considered to determine social behaviours towards others. An individual's perception of those behaviours, rather than the behaviours themselves, was seen as a mediating factor in determining positive outcomes such as popularity, liking, and satisfaction.

In their study of 264 student couples Davis and Oathout (1987) found support for this model. Specifically, they found that higher levels of perspective-taking and empathic concern were associated with couples engaging in more positive social behaviours and less negative behaviours towards their partners. In contrast, personal distress had the opposite pattern. Social behaviours were found to be associated with partner perspective and positive partner perspective accounted for about one third of the variability in partner satisfaction. In a later study Davis and Oathout (1992) found support that anxiety had a moderating influence on dispositional empathy in the expression of some positive behaviours but not for negative behaviours.

The three stage model proposed for the current research was developed independently and from a therapeutic perspective. Consistent with this perspective, empathic interactions were viewed as commencing with an interpretation stage where one seeks to understand the thoughts and feelings of another. This is followed by an appropriate response that would typically result in positive outcomes. This model is more parsimonious than the one proposed by Davis and Oathout (1992) as it combines the second and third stage of their model into a single stage and omits the personal distress variable used by these authors. The exclusion of the personal distress variable requires some comment as it has been found to be associated with helping behaviour (e.g., Batson, 1991; Batson et al., 1983; Davis & Oathout, 1987; Eisenberg et al., 1989). However, the motivation to help was generally associated with reducing personal distress or anxiety. This motivation was considered a non-empathic mode of responding to another and remained excluded from the current model.

The Three Stage Model of Empathy

The proposed model is represented in Figure 1. The first stage involves recognition and interpretation of another's affect, and the second stage comprises an appropriate behavioural response based on that interpretation. These two stages of the empathic process are expected to lead to specific outcomes as indicated by stage three in Figure 1.

For example, a child who observes another child fall off their bicycle and hurt their knee, may *feel* (to some extent) and *know* what the other child is feeling (as they have experienced this situation several times themselves), and then offer assistance to the child in distress. The child who was assisted may feel comforted and soon return to bike riding. The esteem of the child who helped may receive a boost from the praise received from an adult who happened to witness the intervention. Alternatively, consider the following couple interaction. A woman on arriving home from work describes to her partner an altercation that occurred with her boss that day. Her partner listens attentively and begins to feel and understand how she must have felt during the interaction with her boss. He reflects back to his partner an accurate understanding of what happened during the altercation. She feels heard and understood while he gains a better understanding of her work environment. This type of interaction is likely to provide a positive outcome for each partner and contribute to increased satisfaction with each other and the relationship.

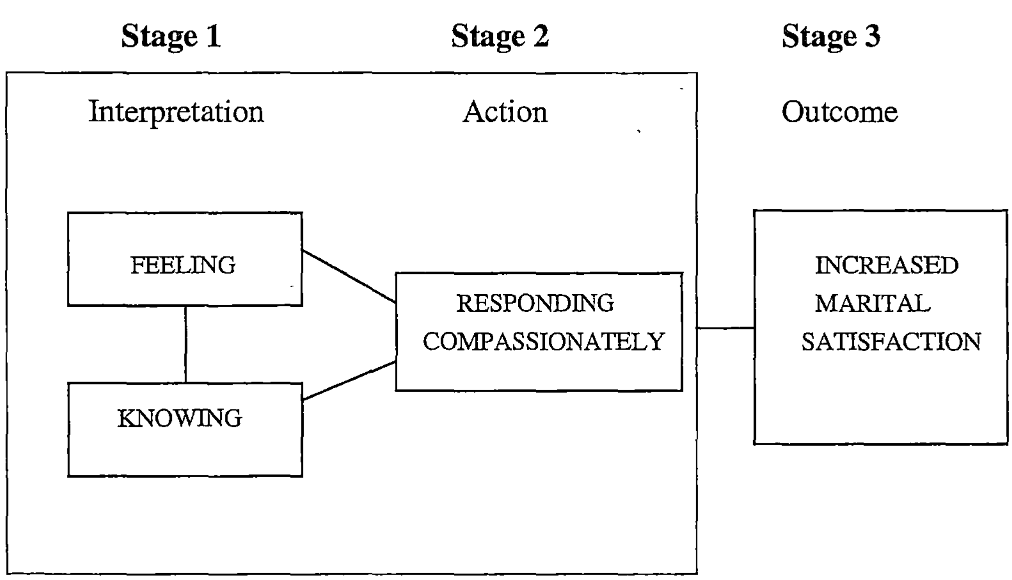

Figure 1. The proposed relationship between the empathic process and an outcome variable.

The model indicates that knowledge of another's affect is a prerequisite to responding appropriately to that affect. An appropriate response without understanding another's affect would typically be mechanical, incongruent, perceived as not being genuine, and signify a lack of empathy (e.g., Bolton, 1987; Egan, 1994; Rogers, 1980).

The interaction between feeling and knowing. It is proposed that accurate understanding of another's affect is based on a combination of physiological and cognitive information as indicated by the two-way connection between the *feeling* and *knowing* component in Figure 1. This association between physiology and cognition is well established in the clinical literature, particularly in relation to anxiety disorders (Bourne, 1990; Markway, Carmin, Pollard, & Flynn, 1993). For example, asking a phobic subject to imagine a feared situation (such as public speaking or a spider) will generally result in the same physiological arousal (such as increased heart rate or sweaty palms) that is experienced in the phobic situation (Wolpe, 1958, 1973; Wolpe & Wolpe, 1988). Alternatively, requesting a client who experiences panic attacks to hyperventilate may induce thoughts of panic (e.g., Craske & Barlow, 1993). These examples illustrate how cognition can influence physiology and physiology can influence cognition to establish an understanding of personal behaviour. It is considered that these well established pathways between cognition and physiology are likely to be invoked to aid understanding of another's affect. Information combined from both modalities would then provide a more complete understanding of another's affect and establish the basis for an appropriate empathic response.

The importance of the interaction between cognition and affect is reflected in Carl Rogers' (1959) statement that "The state of empathy, or being empathic, is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person, but without ever losing the "as if" condition" (Rogers, 1959, pp. 210-211).

The interaction between cognition and physiology is also evident in MacLagan's (1960) description of empathy as an "...imaginative "feeling oneself into" the experience of the other, an emotional "identification" of ourself with the other..." (p. 211). In both cases a cognitively mediated emotional connection is described. However, an affective mediated cognitive awareness of another's emotional world is equally plausible. This direction of action is reflected in Hoffman's (1976) definition of empathy as "...the involuntary, at times, forceful, experiencing of another person's emotional state. It is elicited either by expressive cues which directly reflect the other's feelings or by other cues which convey the affective impact of external events on him" (p. 126).

Feeling the affect of another. The ability to feel to some degree, the affect of another, to partake "...of the quality and not the degree of feelings..." is considered to be one of the primary components of empathy (Greenson, 1960, p. 418). From a developmental perspective, this ability is present in a rudimentary form during infancy where the baby is perceived as experiencing the emotions of others via emotional contagion and imitation of another's affect (Zahn-Waxler & Radke-Yarrow, 1990). This may be observed when an infant cries in response to hearing another baby cry or smiles back at an adult who is smiling at them. Hoffman (1990) lists emotional contagion and mimicry of another's affect as involuntary modes of empathic response. To these two he adds the third involuntary mode of conditioning, where the affective empathic response is due to appropriate cues.

Between 18 months and 2 years of age toddlers become aware that self and other are separate entities (i.e., self-other differentiation), and that other people may have emotions that are different from their own (Ungerer et al., 1990). This awareness provides the basis for perspective-taking - the ability to adopt the frame of reference of another to see what the world looks like from their point of view - which is considered to be pivotal in developing a genuine empathic response (Rogers, 1980). Thus, by 2 years of age children may experience the feelings of others via emotional contagion, mimicry, conditioning, and the cognitively mediated mode of perspective-taking. With continued cognitive and language development, perspective-taking ability improves. Socialisation and learning experiences also assist the growing child to become more adept at identifying more complex emotions. By late childhood information about another's affect or situation may also result in empathic arousal (Hoffman, 1990).

To achieve a shared emotional state via the involuntary modes, similar prior learning experiences may increase the likelihood that induced physiological changes receive the same emotional label by both individuals. In contrast, detailed knowledge of another would assist in producing a shared feeling component via the cognitively mediated modes of perspective-taking or role-taking.

Much of the controversy in the empathy literature stems from the feeling component of empathy. As this component is also central to the current research some comment and elaboration is appropriate. A key issue is the degree to which one individual can actually experience what another person feels. Within a therapeutic framework the most defensible position, and the one adopted by most researchers, is that one achieves, at best, an approximation of the other's affect. From a therapeutic point of view this position is appropriate because when the "..."as if" quality is lost, then the state is one of identification" (Rogers, 1959, p. 211). The loss of objectivity threatens the therapeutic relationship and empathy may be replaced by sympathy, which is considered to be a non-empathic response in the therapeutic context. As discussed by Greenson (1960) "Empathy is to be differentiated from sympathy since it does not contain the element of condolence, agreement, or pity essential for sympathy" (p. 418). Similarly, Bolton (1987) distinguishes between apathy, empathy and sympathy. Apathy is uninvolved and typically expressed as 'I don't care' or 'that's your problem'. However, empathy "...involves experiencing the feelings of another without losing one's own identity" (p. 271). Empathic responses are of the type 'It sounds as if you were really hurt by that'. In contrast, sympathetic responses are of the type 'you poor thing' or 'I feel just dreadful for you'. From this discussion sympathy emerges as a 'feeling for' response, whereas, empathy is a 'feeling with' response.

Thus, in the client-therapist relationship, when the empathic sharing of affect occurs, it is generally considered to be a process where the therapist 'feels along with' the client for a time yet never quite loses their sense of objectivity.

It is noteworthy that consistent *loss of objectivity* is generally considered to signify the absence of empathy. This may occur due to the listener becoming entrenched in a sympathetic mode via sharing of affect. In this instance the sharing of affect would not signify empathy. Therefore, in some circumstances the outcome of shared affect may indicate the presence or absence of empathy. In other circumstances the context or the process whereby shared affect occurs will be important. For example, shared affect via emotional contagion in a non-distressed couple relationship is likely to lead to an empathic response. However, if this occurs in a distressed relationship the outcome may be anger and discomfort, followed by withdrawal from the uncomfortable situation.

On the issue of shared affect, MacLagan (1960) suggests that emotional contagion, such as when panic spreads through a crowd, needs to be distinguished from empathy. Similarly, the emotional contagion that is postulated to occur in infants cannot be considered a mature empathic response, because this requires 'self-other differentiation'.

Greenson (1960) also differentiates an empathic response from the vicarious experience of feeling the joys and sorrows of an actor in a play. He acknowledges that imitation and mimicry have some features in common with empathy but differ in that they are conscious phenomena and limited to copying the external behavioural characteristics of an individual. Greenson asserts that neither strategy (imitation or mimicry) taps the feeling domain of what the other person *actually* experiences. Nevertheless, these strategies are developmentally relevant in assisting young children to understand and label affective states. Additionally, the use of imitation and mimicry by adults may be valuable tools to access the feeling state of another (e.g., Eisenberg, Murphy, & Shepard, 1997; Levenson & Ruef, 1997).

In summary, the feeling component of empathy is an important element in the empathic process that provides affective information that can improve our understanding of the inner world of another. However, the sharing of affect is simply a marker for the presence of empathy. Thus, prior to declaring a specific instance of shared emotion as demonstrating empathy, it is important to consider how the shared emotional states occurred, the age of the participants, the context, and possibly the outcome of the shared emotions.

Knowing the affect of another. This is a cognitive awareness of the feeling state of another. The developmental literature suggests that the growing child first learns to decode primary emotions such as happy or sad. Then via socialisation in conjunction with cognitive development, the ability to decode more complex emotions such as fear, shame, and guilt is acquired. For example, it was demonstrated that from 3 years of age children were capable of differentiating 'happy' from 'sad' when presented with the story of an incident that occurred to another child and asked to select the emotion (happy, sad, angry, afraid) that the other child was most likely to feel from a choice of four faces (Borke, 1971). However, the ability to accurately identify anger became evident from 4 years of age and clearly established by 5 years of age. By late childhood, knowledge of another's life circumstances may also be taken into account to establish knowledge of the affect of another (Hoffman, 1990). Oliver (1975) considered that to know the feelings of another one requires the ability to "...be able to detach himself from his own position...be able to actively construct another person's point of view..." and "...he must get it right" (p. 119). Detailed knowledge of another's life situation, including their beliefs and value systems, plus the rules and assumptions that they apply to everyday living were viewed as assisting one to attain an accurate understanding of another's affect. Smither (1977) contended that empathic understanding was enhanced by 'shared experience' between two people, detailed interpersonal knowledge, and information of the context in which the original emotion was experienced. Smither also emphasised that perspective-taking ability was an important skill that assisted in developing empathic knowledge of another's affect.

Compassionate response to the affect of another. For genuine empathy to occur a suitable compassionate response to the affect of another is also required (Greenson, 1960; Rogers, 1980). This is the third component of empathy, which is dependent on an accurate understanding of another's affect. From a developmental perspective it has been suggested that the ability of the mother to synchronise her affect to that of the infant facilitates the later development of the empathic response in the growing child (Thompson, 1987). However, knowledge of how to respond in different contexts is also required and appears to be related to socialisation. In this regard some researchers place particular emphasis on the quality of parent-child interactions. This is because parents are the first role models of appropriate behaviour for children (Zahn-Waxler & Radke-Yarrow, 1990).

MacLagan (1960) considers that an accurate understanding of another's experience results in 'active sympathy', which is a concern for the other. It is this concern that drives the compassionate response. It is also his view that empathic understanding will automatically lead to a concern for the other unless there is a psychological blockage where, for example, the listener is overly self absorbed, an egoist, or suffering from a mental illness.

Feshbach and Feshbach (1969) in their study of empathy and aggression, found to their surprise, that four to five year old boys, high in empathy, were rated by their teachers as more aggressive than their low empathy counterparts. In contrast, for six and seven year old boys the opposite was found. No differences in aggression were found between high and low empathy girls in either age group. The authors cited maturation as a likely reason for these results plus the possibility that teachers rate aggression in boys and girls differently. They also suggested that the distress exhibited by the person, who is the brunt of aggression, may produce stress in the aggressor and inhibit further attack. Thus, empathy could be a mediating factor in the self-limiting of aggression. A similar conclusion was arrived at by Mehrabian and Epstein (1972) who, in two experiments, found that those with higher levels of empathy administered lower levels of shock to a 'slow learning' subject when the subject's level of distress was immediately visible than when the subject was in another room. In accordance with the view that empathy can reduce aggression Golland (1981) advocates the teaching of empathy to reduce human destructiveness.

Hoffman (1976) views empathy as a natural and relatively automatic response to the distress of another which, via the process of socialisation and cognitive development, may be later transformed into altruistic behaviour. However, when investigating the literature on helping behaviour the theme emerges that helping behaviour, in some contexts, may result more from a desire to reduce personal distress than from altruism or empathy. For example, Batson et al. (1983) found in two studies of helping that when the predominant response to the plight of another was personal distress participants helped less when escape was easy. In contrast, when the predominant response was empathy participants helped independent of how easy it was to escape without helping. These findings were interpreted as indicating an egoistic motivation to reduce personal distress for the first group and altruistic motivation to help for the second group. Similarly, Davis and Oathout (1987) found that the reduction of personal distress or anxiety was associated with positive behaviour towards romantic partners. These results for helping behaviour indicate that knowledge of the motivation for helping may enable one to distinguish between empathic helping and other reasons for helping behaviour.

Overall, the literature supports the idea that an appropriate compassionate response to the plight of another is relatively automatic for those with high levels of empathy. However, this idea must be tempered with the findings that several impediments may obstruct or override a compassionate response in specific contexts. Some of the potential impediments identified include high levels of personal distress (Batson et al., 1983), egoism, and self absorption (MacLagan, 1960).

The outcome of empathy. Empathy is not simply an end in itself but provides the basis for positive outcomes (Egan, 1994). This attribute of empathy is emphasised in the client-therapist literature where empathy is considered an important therapist variable which mediates positive client outcome (Bolton, 1987; Rogers, 1980). However, outside of the client-therapist literature little research has focused on assessing specific outcome variables (an exception is the multidimensional study of Davis & Oathout, 1987). In general, the literature to date has focused more on the first two stages of the model where different measures of the feeling and knowing components of empathy were related to specific responses such as helping behaviour. The inclusion of the third stage in studies of empathy is expected to accelerate theory development and hypothesis testing. For example, the extensive work of Nancy Eisenberg and her colleagues on prosocial behaviour and dispositional empathy (e.g., Eisenberg et al., 1989, 1994; Eisenberg, Fabes, Murphy, Karbon, Smith, & Maszk, 1996) may benefit from the application of a multidimensional model of empathy.

For the current research the approach adopted was that affective knowledge of another would lead to a positive outcome, and that assessment of outcome was required to fully examine the empathic process.

Chapter 3

Early Studies of Shared Physiology in Dyadic Interactions.

Chapter 3

Early Studies of Shared Physiology in Dyadic Interactions.

Background

In this chapter a selection of the early studies from which the concept of physiological linkage emerged are reviewed. These early studies began examining the conditions in which both members of a dyad exhibited a similar physiological response. The results of several studies indicated that a range of variables was implicated in producing similar physiological responses in both members of a dyad. In some instances it was likely that the presence of empathy mediated this outcome (e.g., DiMascio, Boyd, & Greenblatt, 1957). Alternatively, dislike or perceived threat was likely to underlie the similarity of physiological response in other contexts (e.g., Kaplan, Burch, & Bloom, 1964). What emerged from these studies was that the interaction that was occurring between a dyad was producing these physiological outcomes. Also, the results suggested that, at times during interactions, the physiology of one member of the dyad was following the physiology of the other member of the dyad. Thus, the physiological responses of members of a dyad were considered to be *linked* under certain conditions. These earlier studies will now be described and the inferences that may be drawn from them will be outlined.

Psychophysiology and Early Studies of Shared Physiology

Sternbach (1966) defined psychophysiology as "*...the study of the interrelationships between the physiological and psychological aspects of behavior*" (p. 3). He distinguished psychophysiology from the related area of biological psychology. In the latter, one typically manipulates a physiological variable, observes the changes in behaviour, and postulates an intervening internal event to explain the outcome. An example could be where one administers a drug and examines its effect on the performance of a particular task. In contrast, for psychophysiological research "Mental or emotional or behavioral activities are made to occur while physiological events are being observed; correlations between these activities and the observed physiological events are noted, and then some intervening internal event is postulated" (p. 2). Thus, psychophysiologists attempt to infer relationships between physiological and psychological states. This approach was adopted for the current research.

The concept of physiological linkage emerged from early studies of the psychophysiology of client-therapist interactions where the presence of shared physiology was demonstrated in dyadic interactions. In a single case study, DiMascio, Boyd, and Greenblatt (1957) examined how the measures of heart rate (of therapist and client) and skin temperature (of client only) were associated with the verbal exchange that occurred between a client and therapist over 12 psychotherapy sessions. An observer watched each session via a one-way mirror and continuously coded the number of client responses under the categories of 'disagreement', 'showing tension', or 'antagonism', and 'tension release'. They found that the skin temperature of the client increased when antagonism was expressed, but was unrelated to the other affective categories. However, the heart rate of client and therapist were found to be linked when the client expressed tension (both heart rates increased), tension release (both heart rates decreased) or antagonism (client heart rate increased, therapist heart rate decreased).

These results were interpreted as suggestive of a positive 'physiological identification' of the therapist with the client during the expression of tension or tension release by the client, and as a negative identification when the client expressed antagonism towards the therapist. Although the physiology of the client and therapist were moving in the same direction during client expression of tension and tension release, the authors stopped short of inferring a shared emotional state, or an empathic connection between therapist and client under these conditions. Similarly, the absence of shared physiology during the expression of antagonism resulted in no inferences regarding shared emotions or empathy. As commonality of emotional state during shared physiology was not assessed, the inferences that could be made from shared physiology in this study were limited. Another limitation of this study was that social interaction measures were only derived for the client. Thus, one cannot determine if or how the therapist's social interaction actually influenced client response.

Greenblatt (1972) provided some valuable comments on the range of studies of the psychotherapeutic interview that were carried out at the Massachusetts Mental Health Center in the 1950s. He indicated that the team learned most from one client-therapist dyad over 44 interviews. Although there were some initial concerns that the presence of physiological measuring devices would interfere with the therapeutic process, they found that this was not the case and positive client outcomes were achieved over the duration of the trials. With regard to physiological exchange Greenblatt commented that "The patient's reactivity was matched to an extent by the psychiatrist's physiological reactivity" (p. 6). This indicated an interaction at a physiological level between client and therapist. Of interest was that the physiological changes in the therapist were in the same direction, but lower than those in the client. This was interpreted as indicating that the therapist was better able to handle the client's anxiety than the client.

Greenblatt (1972) further noted that physiological concordance (or shared physiology) was not always present during interviews. After each interview the psychiatrist provided a self report measure of how well he was able to listen to and understand the client during the interview. It was found that, in general, the interviews when the psychiatrist was somewhat preoccupied and less able to listen to the client (low empathy) were precisely those interviews during which physiological concordance was most likely to be absent. The conclusion was that the psychiatrist's ability to engage in empathic listening mediated the shared physiology that occurred during the interviews high in empathy. This result provides support for the proposition that empathic listening may provide a pathway for the sharing of physiological states, as suggested in the three stage model of empathy.

Greenblatt (1972) also speculated if physiological concordance would occur with all interacting dyads. If this was accurate then shared physiology could be a fundamental connection that occurs when people interact. Another question posed by Greenblatt was whether different physiological parameters within dyads were correlated. For example, would the heart rate of one member of the dyad be correlated with the skin conductance of the other member of the dyad? Given that some individuals tend to respond more in a particular physiological system (i.e., stimulus response stereotypy), this is an intriguing question that could be investigated providing z-scores or residualised change scores were used to compare across physiological parameters.

In another client-therapist study, Dittes (1957) found an association between client skin conductance and the perceived level of *permissiveness* and *gentleness* in the therapist when the client was discussing embarrassing sexual situations. However, this relationship only held for low but not high ratings of permissiveness and gentleness in the therapist. Therefore, one could not conclude that skin conductance was a direct measure of the client's difficulty in discussing sexual themes.

From a therapeutic perspective the following alternative explanation is offered for these results. The presence of low permissiveness and gentleness in the therapist did not provide a safe context for the client to disclose embarrassing material. The client became aware that the therapist was judgmental from the therapist's verbal and non-verbal communications. As a result the client became sensitive and alert to signs of disapproval from the therapist. It was likely that the client's sensitivity and close attention to the therapist produced the resulting physiological association at low levels of permissiveness and gentleness in the therapist. In contrast, for high levels of permissiveness and gentleness in the therapist the threat to the client's self esteem was minimal. This could result, on average, in a lower level of watchfulness in the client and physiological disengagement from the therapist while the client focuses on telling their story. Overall, the results of the Dittes (1957) study provided indirect support for the proposition that perceived threat is associated with shared physiology.

Malmo, Boag, and Smith (1957) examined the interaction between patient physiology and examiner or interviewer's physiology under conditions of praise and criticism. Nineteen female patients, matched on psychiatric diagnosis, age, educational background, and intelligence were divided into two groups (praise and criticism). Measures of heart rate, neck tension, and speech muscle tension (by chin electromyography) were recorded for patients, the examiner, and the interviewer. The sequence was that the examiner administered a Thematic Apperception Test (TAT) card to each patient and then either praised or criticised the patient's response. This was followed by a 20 s rest pause, scripted positive remarks by the examiner, and another rest pause. Then the interviewer replaced the examiner and questioned the patient about the first part of the experiment. A Second Questioning Period, Brief Reassurance and More Reassurance followed this. There was a 20 s pause between each interaction segment.

Results indicated differential physiological responses for both patient *and* examiner during rest periods following *praise* or *criticism* of the patient by the examiner. In the first rest period, following administration of the TAT card, only patients who were praised showed a significant decrease in speech muscle tension. A similar result was found for the examiner in the praise condition but only for the second rest period following the TAT (that is, after the examiner delivered a brief reassurance to each patient). No effects were found for patient heart rate during the TAT segment. An interesting finding however was that on the examiner's "bad days" (as indicated by self report) patient heart rate was significantly elevated in comparison to the examiner's "good days". This result suggested an interaction of patient physiology with examiner feeling state. However, it was unclear how praise or criticism affected outcome independent of the examiner's mood, as the data was not separately analysed in relation to examiner feeling state.

For the interviewer section, the combined patient group exhibited reductions in speech muscle tension in the rest periods following reassurance, in comparison to the questioning segments. For heart rate, the criticised group had significantly higher levels than the praise group during the intermission (while waiting for the interviewer to commence). Also, the change in heart rate was higher across the intermission and interview segments for the group that were criticised. No effects were found for interviewer speech muscle tension or heart rate. Additionally, no effects were found for chin tension for any of the participants.

This study demonstrated that praise and criticism had differential effects on the physiology of patients and the examiner. Following praise by the examiner a reduction in speech muscle tension occurred for the patients in the first rest period and for the examiner in the second rest period. Similarly, reassurance by the interviewer resulted in reduced speech muscle tension for the patients. Thus, praise or reassurance had a similar physiological outcome for both the examiner and the patient.

The absence of clear findings for heart rate could be because heart rates were generally high throughout for both the examiner and patients. For example, the examiner's average heart rate was 99.3 beats per minute (BPM) on good days and 109.2 BPM on his bad days. Patient average heart rates were similarly high (greater than 90 BPM) except for the praise group in the interview segment when the heart rate was 87.7 BPM. Given that normal heart rate is, on average, 72 BPM (Andreassi, 1995), it was likely that patients and examiner were generally stressed, tense, or highly aroused throughout this study and the examiner began to relax after his segment was completed in the praise condition (as indicated by reduced speech muscle tension). In contrast, heart rates of patients in the praise condition reduced over the TAT session, reduced considerably between the TAT and interview session, and remained at a consistently lower level until after the interview session. This was consistent with tension reduction following praise. The group that was criticised only began to show significant heart rate reduction during the interview segment (where reassurance was provided). Unless there were systematic differences between the two groups in resting heart rate or heart rate response, patients in the criticised group had not yet returned to resting heart rate by the end of the study. Thus, longer habituation to the experimental situation and suitable baseline measures may have strengthened the analyses in this study.

Kaplan, Burch, and Bloom (1964) in their review of the client-therapist studies of the 1950s argued that the covariation of physiology between therapist and client might reflect that the content of the interaction had a similar level of significance for both parties. In accordance with this view they hypothesised that dyads who liked *or* disliked each other would have higher levels of physiological covariation than dyads who were neutral with regard to liking or disliking. In Study 1, male medical students were allocated to one of three four-man discussion groups on the basis of liking or disliking other group members. These groups met for 45 min on five occasions to discuss five different topics expected to be of interest to medical students. In the positive group all participants liked each other. In the negative group all participants were disliked by one other member. The mixed group comprised some that liked, disliked, or were neutral towards other members of the group. The meetings were recorded and the recordings were synchronised with the continuous measures of electrodermal response taken for each participant. The unit of analysis was dyads who liked, disliked, and were neutral. This resulted in seven positive, four negative, and seven neutral pair groupings.

The first analysis examined how often dyads who liked, disliked, or were neutral towards each other exhibited physiological covariation (on the basis of the frequency or amplitude of skin response within 1 min epochs being correlated above $r = .29$). The unexpected results were that physiological covariation occurred most often between dyads that disliked each other and there were no differences in the frequency of physiological covariation between dyads who liked each other or who were neutral.

The second analysis examined how often physiological covariation occurred when individuals engaged in specific social interactions (on the basis of 12 social interaction categories) with someone they liked, disliked, or felt neutral towards. The results were that positive and negative pairs were equally likely to exhibit physiological covariation when they interacted with each other and both groups covaried physiologically at a higher level than when neutral pairs interacted with each other.

The combined results indicated that the overall higher level of physiological covariation exhibited by negative dyads (from the first analysis) was not simply due to overt social interactions, but was also maintained by negative dyads in the absence of overt interactions (from the second analysis). The authors interpreted these results as suggestive of a higher level of sensitivity between negative pairs that may arise due to a mutually perceived threat. Thus, negative pairs did not interact more often than positive pairs but were physiologically linked more often than positive pairs. This suggests that negative pairs were paying close attention to each other even when they were not engaged in overt social interactions.

Kaplan et al. (1964) considered that this study had some major limitations. One of these was the uneven distribution of dyads across the primary categories of positive (seven dyads), negative (four dyads) and neutral (seven dyads). Also, while the unit of analysis was the dyad, all interactions actually occurred in groups of four. Lastly, participant perception of the interactions was not measured. All of these factors separately or in combination may have affected the results of the study. They addressed these methodological issues in Study 2 where female nursing students were allocated to one of 10 positive, 10 negative, and 11 neutral dyads on the basis of their ratings of liking (positive), disliking (negative), or neutral feelings towards the other member of the dyad. Dyads met on one occasion to have two successive 20 min discussions. In one discussion, a topic about which they held the same strong opinion was addressed. In the other they attempted to resolve differences of opinion on a topic about which they held strong but opposing views. Electrodermal responses were taken throughout the discussions. After the discussions each subject rated their own and their partner's role behaviour during the interactions. For the purpose of later analysis, data were combined across type of discussion, as perceptions of role behaviour were equivalent across the two discussion conditions.

The first analysis examined how often pairs were physiologically correlated (on the basis of the frequency of electrodermal responses, in half minute epochs, being correlated at a level greater than $r = .3$). The results were the same as for Study 1 where negative pairs were significantly more likely to be physiologically correlated than either the positive or neutral pairs. For the second analysis, self and partner ratings of role behaviour were divided into high and low and examined across the three types of dyads. These comparisons corroborated the division of participants into pairs who liked, disliked, or were neutral in their feelings towards each other. In Study 2, negative pair members were likely to perceive their partners as participating at a higher level, during the discussions, than the other two groups. This finding supported the postulate of Study 1 that negative dyads have a greater sensitivity to each other's behaviour.

The authors summarised the findings from these two studies for the three groupings of dyads as follows: "(1) Negative-group members were characterized by high participation and highly aggressive behaviour underlying which were strong feelings of hostility for their partners. (2) Positive-pair members were also active and aggressive, but underlying these patterns of behaviour were feelings of warmth and friendliness. (3) Neutral-pair groupings were characterized by affective neutrality and a relatively low degree of participation" (Kaplan et al., 1964, p. 106). The authors speculated that the differences found between negative and positive pairs in these two studies might have been due to the greater intensity of negative affect. They also speculated that in positive pairings there was insufficient threat or competition to produce physiological covariation.

These two studies (Kaplan et al., 1964) indicate that physiological covariation may not always signify the presence of empathy or rapport. This outcome is consistent with the three stage model of empathy where sharing of affect plus an empathic response is required to signify empathy. However, the presence of dislike between dyads, where the highest levels of affective matching occurred, was not likely to lead to an empathic response (e.g., Hallenback, 1981) independent of how well the listener understood the affective world of the other. Exactly how affective matching occurred in these studies is unknown but it was likely that different mechanisms mediated the sharing of affect for positive and negative dyads. Empathic listening is the most parsimonious explanation for the results for dyads who liked each other. However, this is an unlikely explanation for dyads who disliked each other. Mechanisms for the higher levels of affective matching that occurred for dyads who disliked each other may include emotional contagion, which is conceived as a largely automatic process (e.g., Hoffman, 1976), or close attention to the disliked other on the basis of perceived threat.

McCarron and Appel (1971), recognising the interactive nature of client-therapist interviews, investigated whether the amplitude of electrodermal responses was related to therapist verbalisations under two conditions. In the first, a single therapist had 12 therapeutic interviews with the same client. In the second condition, the responses of 12 different therapists (six experienced and six inexperienced) and their clients during an intake interview were examined. Therapist verbalisations during the interviews were classified into the four hierarchical categories: (a) Confrontation (e.g., therapist confronts the client with apparent contradictions in the client's remarks); (b) Interpretation (e.g., therapist provides his understanding of a specific aspect of the client's problem); (c) Interrogation (e.g., "How long did you live there?"); and (d) Reflection (e.g., "Yes, I see."). This hierarchy was based on the level of information transfer from therapist to client in accordance with a communication theory perspective where confrontation was considered to provide the highest level of information (by reducing the amount of uncertainty for the client) and reflection was considered to provide the lowest transfer of information. Based on this hierarchy, it was hypothesised that the therapist *and* the client would exhibit the highest electrodermal response amplitudes to confrontation statements and the lowest to reflection statements. To these four categories a fifth category of Structuring was added for therapist statements that did not fit into the first four and were related to structural aspects of the interview (e.g., "Are you comfortable with the physiological equipment?" or "Our time is up."). Verbatim typescripts were made for each interview and synchronised (± 1 s) with physiological data. For scoring of data a 5 s interval was used for the electrodermal responses of the therapist and the client. For the therapist this interval was calculated backwards from the last verbalisation by the therapist. For the client the interval was from the termination of the therapist verbalisation. The rationale was that the therapists were reasonably aware of what they were about to say and would commence responding physiologically prior to completing their statement. In contrast, the client was most likely to respond at the termination of the verbalisation of the therapist.

Overall results were that differential electrodermal responses were found for clients and therapists under both conditions, and the magnitude of responses generally conformed to the proposed category hierarchy (when the structural category was omitted), with highest responses for confrontation statements and lowest responses for reflection statements. Thus, the fundamental hypothesis was supported whereby both therapists and clients exhibited differential electrodermal responses to different categories of verbal statements by the therapist.

An interaction was found for the 12 therapists and their clients, where client electrodermal response to inexperienced therapists was higher across all verbalisation categories than client response to experienced therapists. It was also found that, except for the structuring category, experienced therapists had higher electrodermal responses across all categories than their less experienced counterparts. These results were interpreted as indicating that inexperienced therapists had greater difficulty with structuring interviews and that this produced increased anxiety for their clients, which was reflected in higher electrodermal responses. In comparison, experienced therapists, who generally exhibited higher levels of electrodermal responses, were viewed as more sensitive and physiologically congruent with their clients. This higher level of responsiveness in experienced therapists may also be viewed as signifying a higher level of empathy or a better ability to 'feel along with their clients', which was reflected in higher and more physiological covariation with their clients. However, this specific aspect of the interaction was not evaluated statistically. The authors noted that, since they had clearly demonstrated the reciprocal nature of client-therapist interactions, it would be appropriate to evaluate also the effect of the client's interactions on the therapist (McCarron & Appel, 1971).

In a later study of client-therapist interactions Roessler, Bruch, Thum, and Collins (1975) examined the relationship between rating of client affect and client physiology during therapy sessions. In this single case study eight therapeutic interviews with a 23 year old female were videotaped. The first three interviews were used for training in rating of client affect on a Likert scale. Three pairs of raters rated the first and last 10 min of four of the later interviews for intensity of affect every 20 s. The original four physiological measures taken throughout the interviews were used to produce eight physiological variables (respiratory rate, respiratory amplitude, heart rate, skin conductance, amplitude of galvanic skin response, number of galvanic skin responses, finger blood volume, and finger pulse amplitude). These were averaged over 20 s periods for later analysis. Results for within interview analysis exhibited considerable variability of correlations between affect ratings and physiological parameters. However, when physiology and affect ratings were combined across interviews, significant correlations emerged between five of the physiological variables and affect ratings (respiratory rate, respiratory amplitude, skin conductance, finger pulse amplitude, and number of galvanic skin responses). The direction of correlations indicated that higher intensity of affect was associated with higher levels of sympathetic activation. The authors concluded that ratings of affective intensity in conjunction with physiological measures might be useful for later studies.

One needs to be cautious regarding the generalisability of these results because they derive from a single case study. Also, there were difficulties with the use of affective rating scales, low inter rater reliabilities, and an absence of measures for the therapist.

In Lacey's (1959) review of client-therapist studies he argued that one should recognise the interactional nature of communication exchange and be mindful of the possible effects on measurement data. This view was supported by the studies reviewed where the interactional nature of dyads and the likely effect on data was amply demonstrated. Yet suitable measures for *both* participants were frequently not used or methodological inadequacies weakened the analysis or interpretation of results.

Lacey (1959) was optimistic regarding the value of further research into dyadic interactions. Despite this, Roessler et al. (1975) noted that fewer than 10 papers were published between 1959 and 1969 on the psychophysiological correlates in client-therapist dyads. They suggested that this might be due to the difficulty of determining if specific patterns of physiology could serve as markers for specific emotional states. This complex issue was not examined in these earlier studies where the focus was frequently confined to whether the presence of empathy in dyadic interactions led to shared physiology.

Robinson, Herman, and Kaplan (1982) argued that, if the concordance of physiology found in earlier studies of client-therapist dyads actually signified empathy, then shared physiology would correlate with a measure of empathy. In their study of 21 counsellor-client dyads, finger temperature and skin conductance for both counsellors (10 female and 11 male) and clients were measured during counselling interviews. Clients were undergraduate students (16 females and 5 males) who attended two half hour interviews to discuss actual concerns. The first interview served as habituation for both counsellors and clients and only data from the second session was analysed. At the end of the second interview the client rated the empathy of the counsellor.

For subsequent analysis, finger temperature was averaged each minute over the 30 min interview. For skin conductance only data from the last 20 min was used in analysis. Skin conductance was divided into three distinct response patterns plus a composite of the three. For two response patterns, the number of small and large conductance responses initiated by either the counsellor or client, followed by a similar response by the other party within 7 s, were counted. In the third category, large conductance responses that were matched by the other party between 7 and 40 s later were counted.

Results were that small and large rapid skin conductance responses (i.e., with a latency of less than 7 s) were significantly correlated with client ratings of counsellor empathy ($r = .453, p < .05$; $r = .617, p < .005$, respectively). No effects were found for skin temperature, skin conductance level for large amplitude and long latency (between 7 and 40 s), or the composite skin conductance level measure. These results demonstrated that empathy was related to the matching of phasic affective activity (as measured by skin conductance level with short latency responses), rather than tonic activity (as measured by finger skin temperature). Thus, it was the dynamic moment by moment sharing of physiology that correlated with empathy. The authors concluded that this result "...adds support to the notion that the development of an empathic relationship is expressed in terms of physiological responding" (Robinson et al., 1982, p. 198).

In their review of counselling research, Robinson and Kaplan (1985) advocated the continued use of psychophysiological techniques to "...evaluate subtle changes in emotion..." during counselling, and to "...elucidate the affective interaction between counselor and client" (p. 91). In particular they considered that "...psychophysiological measurement shows promise as a means of quantifying counseling variables such as empathy" (p. 91). Further, they advocated that more than one psychological construct should be explored. They also recommended measuring more than one physiological parameter to cater for individual response specificity (the tendency for some individuals to respond idiosyncratically in one physiological system).

Summary

In summary, the early studies of the psychophysiology of dyadic interactions provided a range of important results. It was established that during client-therapist interactions physiological covariation occurred, specifically during emotionally charged interactions (DiMascio, Boyd, & Greenblatt, 1957). It was also identified that the presence of shared physiology was associated with the empathic listening skills of the therapist (Greenblatt, 1972). Higher levels of empathy were also associated with the differential findings for experienced versus inexperienced therapists and their levels of shared physiology with their respective clients (McCarron & Appel, 1971). Similarly, the finding of Robinson et al. (1982) that shared physiology was correlated with therapist level of empathy (as rated by clients) corroborated the proposition that empathy may mediate shared physiology.

However, other results indicated that shared physiology does not depend only on therapist empathy. For example, the physiological covariance that occurred in Dittes (1957) study may be explained as resulting from the perceived level of threat to the client's self esteem and sensitivity to negative judgments by the therapist. Also, Kaplan et al. (1964) demonstrated that dyads who disliked each other exhibited higher rates of physiological covariance than those who liked each other. Here the basis of shared physiology was considered to be the perception of mutual threat and a higher sensitivity to the actions of the disliked other.

In other studies, physiological covariance may have occurred as a result of similar levels of anxiety to the experimental situation and the provision of praise and reassurance (Malmo, Boag, & Smith, 1957). Shared physiology may also have occurred in response to the emotional significance of various levels of information transfer (Roessler et al., 1975).

Consequently, shared physiology occurred in empathic and non-empathic contexts. In empathic contexts empathy was frequently implicated in mediating the physiological covariation. In contrast, for non-empathic contexts the presence of anxiety or perceived threat was likely to be the mediating variable. In general, the studies reviewed demonstrated that, when dyads interact, the physiology of one member of a dyad might be linked to the physiology of the other member of the dyad. This indicates that there is an interaction between dyads at a physiological level when dyads interact or attend closely to each other. This proposition extends Lacey's (1959) concept of an interactional communication exchange within dyads to a physiological level.

However, these early studies were unable to demonstrate an unequivocal connection between shared physiology, shared emotion, and empathy. A refinement in methodology and data analysis techniques was required to more effectively delineate these connections.

Chapter 4

Physiological Linkage and Dyadic Interactions.

Chapter 4

Physiological Linkage and Dyadic Interactions.

Background

In this chapter the concept of physiological linkage (where the dynamic physiological response of one person follows the dynamic changes in the physiological response of another) and the statistics that enable one to determine the direction of physiological linkage are introduced. The studies that applied bivariate time-series analysis to examine physiological linkage in dyadic interactions are reviewed in detail. The results of these studies are considered in relation to the three stage model of empathy outlined in chapter 2. Of specific interest for the current research were the absence of findings for physiological linkage and the expression of positive affect during dyadic interactions. It is argued that this was due, in part, to the paucity of positive affect during dyadic interactions, the use of naturalistic interactions versus regulating turn-taking, and the inherent limitations of bivariate statistics to track changes in the direction of physiological linkage throughout the interactions. It is proposed that some changes in methodology would aid an empathic interaction between couples and provide a good test of whether physiological linkage occurs during the expression of positive affect. The background to arriving at this position is discussed.

Bivariate Time-Series Analysis Techniques and Physiological Linkage in Dyadic Interactions

The concept of physiological linkage could not be fully explored until bivariate time-series analysis techniques were introduced into the study of dyadic interactions. John Gottman and his colleagues were largely responsible for this development (Allison & Liker, 1982). Gottman (1979) considered that, since cyclical patterns frequently characterised social interactions, spectral analysis techniques were ideally suited to identify these relationships. This is because the spectral density function of a sequential series of numbers provides a plot of the variance in the series across frequency. Thus, if there is a repetition of an effect over time, such as a drug producing a maximum response at the same time each day or the sales of a company being highest in the same month each year, these features will be indicated by a peak in the spectral density plots of drug across days and sales across years. Similarly, if in a dyad there is cyclicity of behaviour with one person tending to follow the other physiologically, then the spectral density functions for each person will exhibit peaks at approximately the same frequency for physiological parameters. This is a first step in evaluating whether the physiology of one member of a dyad is physiologically linked to the other.

From an information theory perspective, Gottman (1979) proposed that it would be valuable to know, when studying social interactions, if the behaviour of one person reduced uncertainty in predicting the behaviour of the other. In this regard Gottman suggested that "Lead-lag relationships are useful in making inferences about which series is, in some sense driving the other" (p. 339). Knowing who was leading and following during interactions was viewed as providing valuable information for the study of dominance in human and animal behaviour. The mathematical basis of spectral analysis techniques for the calculation of lead-lag relationships in continuous and categorical sequential data was presented in Gottman's (1979) paper.

However, prior to evaluating lead-lag relationships it is important that each series exhibits stationarity. To check for stationarity one examines if the autocovariances (correlations of pairs of observations with increasing time lags between observations) of each series rapidly reduces to zero. Gottman and Ringland (1981) suggest that a good 'rule of thumb' is that autocovariances should be essentially random at a lag of *T*/6 where *T* is the number of sequential observations. It is also important to account for the autocorrelation in each series. That is, how knowledge of the past history of the series enables accurate prediction of future points in the series. For example, in a mother-infant dyad, inspection of the individual spectral density plots could indicate that each series exhibited cyclicity but at different frequencies. In this case both the mother's and the infant's behaviour may be predicted reliably from their past behaviour. Yet their behaviour is independent of each other and not linked. However, their behaviour will 'appear' to be linked when the lead-lag analysis is performed.

To safeguard against this possible error in interpretation of results, Gottman and Ringland (1981) proposed a technique demonstrating that "*we can reduce uncertainty in the infant's behavior from our knowledge of the mother's past behavior, over and above our ability to predict simply from the infant's past*" (p. 398). To achieve this they first compute, for example, the best prediction of the mother's behaviour from her past behaviour (autocorrelation). Then, if the best prediction of the mother's behaviour from the infant's behaviour, when added to the first calculation, significantly improves the prediction of the mother's behaviour, one may conclude that the mother's behaviour is linked to the infant's behaviour. Also the direction of linkage is that the mother is following the infant's behaviour. As this calculation may be computed in both directions one may also determine the converse and evaluate whether the mother's behaviour predicts the infant's behaviour. On the basis of these calculations one may determine if the linkage, in a dyadic interaction, is unidirectional - where one member of the dyad follows the other, or bidirectional - where each member of the dyad is following the behaviour of the other in a circular fashion.

Despite the complexity of bivariate time-series analysis, this technique is better suited to explore the dynamics of interactions than the use of averages or basic correlations. This is because dyadic interactions are sequential and bivariate time-series techniques are ideally suited to analyse sequences. Also, the use of bivariate time-series analysis enables one to explore research questions from new perspectives. For example, one can assess the presence of behavioural or affective dominance during interactions. As discussed by Gottman and Ringland (1981), traditional techniques are frequently inadequate to assess dominance, as the one who is dominant in a relationship does not necessarily speak more often or louder than the other party, yet the other may consistently follow their behaviour. Additionally, the availability of information on bidirectionality in interactions can guide interpretation of results or provide the opportunity to test specific predictions. For example, in the context of perceived threat, one might predict bidirectionality where each antagonistic member is closely observing the other's behaviour.

Overall, bivariate time-series analysis provides new insights into the dynamics of dyadic interactions, but advances in theory development are required to capitalise effectively on this source of new information. Also, these bivariate time-series techniques may be supplemented by traditional statistics as required.

Studies of Physiological Linkage in Dyadic Interactions

Few studies have used bivariate time-series analysis to examine patterns in dyadic interactions. Gottman and Ringland (1981) demonstrated the utility of these techniques in the re-analysis of an earlier study of mother-infant play by Tronnick, Als, and Brazelton (1977). In the original analysis, using running correlations (1-10 s, 2-11 s, 3-12 s, and so on), Tronick et al. concluded that positive correlations between mother and infant indicated that their affective interactions were synchronised and moving in the same direction, while negative correlations indicated the opposite. Gottman and Ringland argued that these conclusions could not be substantiated simply from the use of running correlations. Using bivariate time-series analysis Gottman and Ringland were able to demonstrate that in two mother-infant dyads the mother was predominantly following the infant's behaviour. In a third dyad there was evidence of bidirectionality where both mother and infant were following each other's behaviour. The presence of bidirectionality provided evidence that the infant in the third dyad was also responding to the mother, which could indicate developmental progress in the infant. In this instance the use of spectral analysis techniques provided clearer information about the dynamics of the mother-infant interactions and indicated that the emergence of bidirectionality may signify a developmental progression in these relationships.

In a landmark study by Levenson and Gottman (1983), improved methodology and data analysis techniques were introduced that overcame most of the limitations evident in earlier studies of dyadic interactions. In this study naturalistic interactions between married couples were videotaped during discussions of *events of the day* and an *area of marital conflict*. Four physiological measures were recorded. These were heart rate, pulse transmission time to finger, skin conductance level, and general somatic activity from a transducer that detected movement in the chair. Each 15 min interaction segment was preceded by 5 min silence to provide physiological baseline measures. After the events of the day interaction, couples separately filled in marital satisfaction questionnaires and a marital problem inventory. A specific problem that the couple would attempt to resolve during the conflict segment was agreed upon. Within three to five days following the laboratory session each partner returned separately to the laboratory and provided self ratings of affect while watching the videotape of the original interactions. Affective state was indicated by moving a pointer on a scale where 'very negative' was located at zero degrees, 'neutral' at 90 degrees, and 'very positive' at 180 degrees.

Using bivariate time-series analysis, levels of physiological linkage were computed for the husband and wife on each of the four physiological variables. In this way four pairs of indices were derived. Each index represented the extent to which the pattern of physiological response of one spouse accounted for the variance in their partner's physiological response, beyond that accounted for by their partner's physiological response alone. To determine the direction of the relationship between physiological linkage and marital satisfaction the eight indices were averaged over each interaction segment to provide a single index of physiological linkage for the couple during each segment. This index was found to be significantly correlated ($r = -.31$) with marital satisfaction for the conflict resolution segment but not for the neutral segment ($r = -.04$). That is, lower marital satisfaction was associated with higher physiological linkage during the conflict resolution segment. Subsequent hierarchical multiple regression indicated that physiological linkage during the conflict resolution segment accounted for 60% of the variance in marital satisfaction.

The results also indicated that there was more negative affect and greater reciprocity of negative affect in dissatisfied marriages.

The authors interpreted these results as indicating that couples in dissatisfied marriages were unable to break out of patterns of feeling negative and reciprocating the negative affect of their partner. As the physiological linkage measures were found to be orthogonal to the self affect ratings *and* the averages of individual physiological measures, linkage was considered to be "...tapping a different dimension of the interaction than either of these more traditional measures" (Levenson & Gottman, 1983, p. 596). Thus, physiological linkage provided unique additional information regarding the pattern of interaction.

This study denoted a significant advance in experimental methodology and data analysis techniques for the investigation of couple interactions. The use of continuous self rating of affect enabled direct analysis of this measure with marital satisfaction. In addition, the use of bivariate time-series analysis enabled one to examine whether the physiological response pattern of one spouse was temporally associated with the response pattern of their partner. The use of four physiological measures was lauded by Notarius and Herrick (1989) as the "...first interactional study to sample a broad range of physiological response systems..." (p. 398). This is salient because the use of several physiological measures provided some control for stimulus response specificity and individual response stereotypy (e.g., Stern, Ray, & Davis, 1980).

The results from the Levenson and Gottman (1983) study indicated that there was an association between physiological linkage and lower levels of marital satisfaction when distressed couples attempted to resolve an interpersonal conflict. It was unlikely that empathy was occurring during conflict resolution interactions for distressed couples, given the high levels of negative-affect reciprocity. Application of the three stage model of empathy (developed in chapter 2) to these results would suggest that Stage 2 of the model (i.e., compassionate response) was likely to have been absent. It was likely that there were barriers to empathic interactions such as anger, dislike, or an unwillingness or inability to engage in perspective-taking (e.g., Hallenback, 1981), particularly for already distressed couples attempting to resolve an interpersonal conflict. Thus, the presence of physiological linkage for distressed couples in the Levenson and Gottman study was consistent with the presence of shared physiology found by Kaplan et al. (1964) for dyads who disliked each other.

Gottman and Ringland (1981) agreed that the context in which physiological linkage occurs should be considered when interpreting what the presence of physiological linkage means. For example, when a mother's physiology follows her infant's physiology this is unlikely to indicate that the infant is dominant in the relationship. Rather, the mother is engaging in appropriate caretaking behaviour. If this pattern continued into childhood and later, then this pattern would suggest inappropriate dominance of the child in the relationship. Consequently, when physiological linkage occurs in a dyadic interaction, the context of the relationship, the interactional context, or both, should be taken into account to assist in interpreting the meaning of physiological linkage. Thus, the presence of dominance in distressed relationships warrants consideration as an explanation for the results of Levenson and Gottman (1983) for distressed couples.

The Levenson and Gottman (1983) study concentrated on the results for distressed couples and the relationships between lower levels of marital satisfaction and physiological linkage. The presence of significant levels of physiological linkage for non-distressed couples was not reported. Consequently, it was unclear whether significant levels of physiological linkage were generally absent for non-distressed couples or simply occurred at lower levels than for more distressed couples. The absence of a clear relationship between physiological linkage and higher levels of marital satisfaction is problematic from the perspective of the three stage model of empathy. For non-distressed couples one would expect higher levels of empathy than for distressed couples. Thus, when non-distressed couples interacted it was likely that they knew and understood what their partner was communicating (Stage 1 of empathy). One would also expect that during interactions for non-distressed couples an appropriate empathic response to each other would occur (Stage 2). Yet, physiological linkage was not associated with higher levels of marital satisfaction. This raised the question as to whether physiological linkage was related to empathy in any meaningful way.

One explanation for the absence of an association between physiological linkage and marital satisfaction for non-distressed couples may be found in the inherent limitations of bivariate time-series analysis. This type of analysis can only track if, *on average,* the physiology of one spouse is following the physiology of the other throughout the *entire* interaction. Consequently, the methodology of couples engaging in naturalistic interactions in this study was ideal to track the presence, or absence, of affective dominance patterns in the relationships. However, it may be argued that physiological linkage also occurred for non-distressed couples but was not evident in the analysis because they engaged in turn-taking during the interactions. The proposition is that when each partner listens empathically to the other his or her physiology follows the speaker. Then, if each listens and follows the other physiologically for about half of the interaction (via turn-taking), the overall outcome for the direction of physiological linkage will tend towards zero. This proposition may be evaluated with a change in methodology where turn-taking is regulated during couple interactions.

Three years after the data for the earlier study was recorded (reported in Levenson & Gottman, 1983), 21 of the original 30 couples were contacted. Of these, 19 couples provided follow-up marital satisfaction questionnaires (one couple declined to participate and another was divorced). These results were reported in Levenson and Gottman (1985). Marital satisfaction change scores were computed and partial correlations were used to examine whether the original affective and physiological measures were predictive of the non significant decreases in marital satisfaction that occurred over the intervening 3 years.

Affective ratings during the original interactions, for events of the day and the conflict interactions, were found to be predictive of the decrease in marital satisfaction over the intervening 3 years. Physiological linkage from the original interactions was found to be unrelated to changes in marital satisfaction. However, the simple averages of physiological measures during the baselines (prior to the interaction segments) and for both interactions segments (events of the day and conflict resolution) were strong predictors of changing marital satisfaction. The results were that 14 out of a possible 32 correlations were significant, and two correlations were above $r = .9$. The result for baseline averages led the authors to re-examine the original videotapes of the baseline segments. They concluded that, as the couples were facing each other, had eye contact, and pantomimed messages, baselines also constituted interactions. The overall consistency of these results, for physiological averages, were interpreted as indicating that "The more aroused the subjects were in 1980, the more their marital satisfaction declined between 1980 and 1983" (Levenson & Gottman, 1985, p. 89). Higher heart rates, increased skin conductance, shorter pulse transmission times, and higher levels of somatic activity indicated higher physiological 'arousal'. These findings were considered to be consistent with the earlier results of Ekman, Levenson, and Frieson (1983) who found that higher arousal was associated with the specific emotions of fear, anger, and sadness.

Thus, the original affective ratings (using a rating dial) and averages of physiological measures were found to account for most of the change in marital satisfaction over a 3 year period. The specificity of results in the earlier study (Levenson & Gottman, 1983), where physiological linkage was predictive of the current level of marital satisfaction and in the later study (Levenson & Gottman, 1985) where simple averages of physiological measures predicted changes in marital satisfaction, intrigued and baffled the authors. Levenson and Gottman (1985) suggested that further studies might provide an understanding of the basis of this specificity.

Wagner and Calam (1988), in their review of this study, speculated that data from the 11 couples who could not be contacted for the follow-up may have altered the results. However, they acknowledged that there was little difference in original levels of marital satisfaction between these 11 couples and the 19 included in the follow-up study. Their view was that physiological linkage may represent a dynamic measure of affect within a relationship where "people who see their marriages as being on the decline might become more 'aroused' by trying to avoid destructive interactions" (p. 216).

The idea that physiological linkage captures the dynamic exchange of affect within a dyad was supported by the Robinson et al. (1982) study (see chapter 3 for a review) and the earlier Levenson and Gottman (1983) study. The second concept of high arousability in distressed relationships, combined with avoidance of interactions with their partner during conflict and how to manage high levels of arousal (particularly for men), is an important concept that is explored in detail in Gottman's (1997) book on marital interactions. The concurrence of high arousal and high emotion was supported by earlier studies (e.g., DiMascio, Boyd, & Greenblatt, 1957; Roessler et al., 1975). In addition, support was found for the proposition that higher levels of arousal were specifically related to higher levels of negative affect (Kaplan et al., 1964), and the reciprocity of negative affect (Levenson & Gottman, 1983). From this discussion it is less surprising that Levenson and Gottman (1985) found that the earlier tonic levels of arousal (as indicated by the averages of physiological measures) were more predictive of later marital satisfaction than the dynamic measure of interactive behaviour (physiological linkage) that was 3 years old. It is plausible that tonic levels of physiology may signify the underlying level of stress in a relationship.

In a pilot study of parent-child interactions, additional support was provided for the utility of physiological linkage and the methodology proposed by Levenson and Gottman (1983) for the study of dyadic interactions. Wagner and Calam (1988) noted that the psychophysiology of dyadic interactions was a somewhat neglected area of research and cited the absence of a sound theoretical framework as a difficulty. They concurred that the use of ordinary correlations was inadequate to assess dyadic interactions because sequential observations are not independent, significance tests on the resultant correlations are inappropriate, and that "...measures of cross correlation between individuals in such data are contaminated by autocorrelation (e.g., cyclicity) within the measures on the same individual" (p. 214). Impressed by the methodologically sophisticated approach and results obtained by

Levenson and Gottman, they designed a pilot study to assess the feasibility of using the same procedures for the study of parent-child interactions. In this study six parent-child dyads (with children from 6 to 10 years of age) engaged in three discussions - *events of the day*, *tidying the bedroom*, and *spending the money* given towards expenses for attending the laboratory. Measures of heart rate (using the interbeat interval) and skin conductance were taken throughout the interactions. These discussions were videotaped, lasted from 15 to 18 min, and were preceded by a baseline. Affective facial expressions of the participants were coded into positive or negative (on a seven point rating scale) every 4 s by independent raters. For the physiological measures 4 s averages were also used. The authors argued that 4 s averages would be more sensitive to phasic changes than the 10 s averages used by Levenson and Gottman (1983).

Results were reported for four of the dyadic interactions. For three of the four dyads, bidirectionality was found for affective expression and the parent's heart rate was found to follow their child's heart rate. Results for skin conductance were that for one dyad the parent was following the child and the opposite was found for another dyad. Of interest was that Wagner and Calam (1988) reported the sign of the cross correlations for the dyadic interactions. They contended that this added another level of information about the dynamics of dyadic interactions. For example, for affective exchange there were three distinct patterns: Mutually positive (2 dyads); mutually negative (1 dyad); and absent (1 dyad). The authors concluded that the use of time-series analysis techniques showed promise for the investigation of parent-child dyadic interactions and enabled group comparisons across outcome variables of interest (such as level of satisfaction in the relationship). They also discussed the use of physiological linkage and bivariate time-series analysis techniques in a proposed research program to examine interaction patterns between anorexics and parents.

As Wagner and Calam (1988) used naturalistic interactions and the level of satisfaction was not reported for these parent-child dyads, one cannot determine what the physiological linkage that occurred represented in the context of these relationships. Despite this limitation, this study provided independent assessment and support for the use of bivariate time-series analysis in the study of dyadic interactions.

The studies reviewed so far in this chapter used new methodology that incorporated the use of bivariate time-series analysis. These advances enabled the dynamics of the affective exchange in dyadic interactions to be explored in greater detail than had been possible with more traditional approaches. However, the main study (Levenson & Gottman, 1983) only found significant results in the context of dissatisfaction typically accompanied by the expression of negative affect and the reciprocity of negative affect. In the studies of mother-infant interactions (Gottman & Ringland, 1981) and parent-child interactions (Wagner & Calam, 1988) empathy was likely to have been present. However, these two studies were respectively demonstrational and exploratory and did not specifically examine the issue of how physiological linkage may relate to empathy in the dyadic interactions. As a result there was little evidence to support an association between physiological linkage, positive affect, and empathy.

As speculated by Kaplan et al. (1964), the lower rate of physiological covariation for dyads who liked each other may have been due to the absence of intensity that automatically occurs in the context of threat or dislike of another. Thus, another explanation for the lower level of outcomes for positive affect and physiological linkage may be that these types of effects are more subtle and more difficult to detect. If this was the case then naturalistic interactions may be less suited to detect these more subtle effects. A change in methodology that promotes empathic listening may assist in detecting outcomes for positive affect.

Physiological Linkage and Empathy

The empirical study of empathy is complicated by a lack of agreement on what empathy *is* and how it may be operationalised or measured experimentally. As a result it is not surprising that different self report measures of empathy were found to have questionable reliability (e.g., Cross & Sharpley, 1982) and concurrent validity (e.g., Chlopan et al., 1985; Hickson, 1985) or that studies employing self report measures had low validity with external outcome criteria (Batson, et al., 1983; Eisenberg et al., 1989).

Levenson and Ruef (1992) used a new approach to assess empathy. In their study they considered that the primary feature of empathy was *knowing* because perception of another's feelings was viewed as a likely precursor to feeling and responding compassionately to another person. In accordance with this view, they operationalised empathy as the ability to identify accurately another person's affect. They hypothesised that when "...one person was most empathically (i.e., accurately) perceiving the feelings of another, the two would most likely be in a common physiological state" (Levenson & Ruef, 1992, p. 236). To evaluate this hypothesis four videotaped conversations were selected from earlier studies of marital interactions. Two were conversations of events of the day and two were of marital problem areas. Independent raters (14 men and 17 women) continuously rated the affective state of a target spouse in two of the four videotapes. In one tape the target spouse was the wife and in the other the target was the husband. While the rater viewed and rated the videotape, continuous measures of the rater's responses on the same physiological variables used in the original study were taken.

Results showed that significant physiological linkage with the target spouse occurred for 33% of the physiological variables in the first tape and 28% in the second tape. The average rating accuracy (rater agrees with subject rating of affect) varied from 28% to 43%. No gender differences were found for raters in level of physiological linkage or accuracy of rating positive and negative affect. Rating accuracy for negative affect was found to be uniquely associated with measures of physiological linkage with the strongest relationships (positively correlated) for skin conductance and pulse transmission time to finger. For positive affect the means of individual physiological measures (finger pulse amplitude, slower heart rate) were associated with rating accuracy whereas physiological linkage was unrelated. In addition, rating accuracy was found to be unrelated to traditional empathy scales, the rater's perceived accuracy, or their own marital satisfaction. The authors concluded that a physiological substrate of empathy was demonstrated, as the rating accuracy of negative affect was uniquely associated with physiological linkage, whereas rating accuracy of positive affect was associated with lower cardiovascular arousal.

The results of the Levenson and Ruef (1992) study provided support for the proposed interaction between the feeling and knowing components during Stage 1 of the three stage model of empathy. In the model the first stage of empathy was also expected to lead to a cognitive and emotional understanding of another. The proposed interaction between feeling and knowing was supported in this study: Cognitive knowledge of the feeling state of another was demonstrated by the accuracy of rating the other's affect and feeling what another is feeling was demonstrated by physiological linkage between the rater and the target spouse. That these two elements of empathy were interacting to provide an accurate understanding of the feeling state of another was supported by the positive correlation between rating accuracy and physiological linkage.

Within the three stage model of empathy, accurate understanding of another's affect was considered to provide the basis for an appropriate empathic response to the other. However, as there was no direct interaction between the rater and the spouse being rated, a full empathic interaction was not possible. Notwithstanding this limitation, the results of this study provided strong support for the contention that shared physiology represents shared feeling. As the context was empathic and non threatening it is difficult to attach any other meaning to the presence of physiological linkage than shared feeling between the rater and the target spouse. However, whether physiological linkage (or shared emotion) enabled accurate rating of affect, or accurate rating of affect resulted in physiological linkage, or whether both factors interacted, remains speculative. Levenson and Ruef (1992) favoured shared emotions rather than shared cognitions as the basis for their results. As these factors were not specifically measured in this study the authors acknowledged that adjudication between the two was not possible.

Synthesis of the Research Findings on Physiological linkage

The two main studies outlined have found physiological linkage to be associated with lower marital satisfaction (Levenson & Gottman, 1983) *and* the ability to accurately identify another's negative affect (Levenson & Ruef, 1992). These contrasting results indicate that physiological linkage occurs under at least two conditions: (a) the expression of negative affect between distressed couples when attempting to resolve a marital conflict; and (b) during perspective-taking when negative affect is being expressed. The first condition is one of conflict and distress, which may resemble a basic threat response while the other is one of empathic listening. One explanation for the presence of physiological linkage under these different conditions is that different underlying mechanisms are invoked in each condition. For example, in the 'threat' condition one could hypothesise a relatively automatic mechanism similar to, or part of, our normal threat response system. In the other condition, a more cognitively mediated response could be anticipated. Clearly, further studies are required to elucidate these possibilities.

The salience of negative affect with physiological linkage. Both studies cited found significant relationships between physiological linkage and negative affect but not for positive affect. In the earlier study it was noted that "...physiological linkage occurs in the context of negative-affect expression and exchange" (Levenson & Gottman, 1983, pp. 595-596). The interpretation advanced for these results was of couples being unable to break out of a pattern of negative-affect reciprocity. As such, the observed relationship between physiological linkage and negative affect may represent affective dominance, a basic threat response, or a combination of both. Also, as discussed earlier, the salience of results for negative affect may also be due to the high levels of arousal associated with negative affect or the predominance of negative affect in studies where significant results emerged. Thus, it remains to be resolved if physiological linkage occurs only in the presence of negative affect.

The absence of physiological linkage for positive affect. Physiological linkage was absent with regard to the expression of positive affect in the two main studies outlined above (Levenson & Gottman, 1983; Levenson & Ruef, 1992). For the second study (Levenson & Ruef, 1992), the absence of significant correlations between physiological linkage and rating of positive affect may simply be due to the fact that there were few segments of positive affective interactions on the videotapes (i.e., an average of 36 negative periods and 7 positive periods, out of a total of ninety 10 s segments per videotape). This possibility was acknowledged in a footnote by the authors. Alternative explanations for the absence findings for significant relationships between positive affect and physiological linkage include: (a) the use of naturalistic interactions in the Levenson and Gottman (1983) study, which favoured the emergence of natural dominance patterns that may have been present in the relationships; (b) the possibility that the physiological dynamics for positive affect are more subtle that those for negative affect; and (c) the inherent limitations of bivariate time-series analysis to determine outcomes for positive affect as a result of (a) and (b), but more particularly because of the general absence of positive affect in these two studies.

The Current Research

The current research sought to investigate whether physiological linkage occurred during the expression of different types of affect. From the proposed three stage model of empathy it was expected that, if physiological linkage represented the feeling component of empathy, physiological linkage would occur during the expression of neutral, positive, or negative affect in dyadic couple interactions. In the current research it was proposed to test this hypothesis by investigating whether couples in satisfied relationships, when asked to listen empathically to their partner, were physiologically linked.

Chapter 5

Methodological Issues

Chapter 5

Methodological Issues

The methodology and bivariate time-series analysis techniques for investigating the physiology that occurs during dyadic couple interactions was new to the University of Tasmania. As a result a wide range of methodological, data synthesis, and data analysis issues required resolution. In this chapter these issues and their solutions will be described.

MacLab™ Physiological Recording System and Channel Allocation

An eight channel MacLab system was used to record physiological data. The MacLab is an integrated system that provides specialised front-end interfaces to which physiological pick up devices may be attached. The front-end interfaces also provide additional gain, filtering, coupling of physiological signals, plus electrical isolation to ensure the safety of participants from potential power surges or electrical faults.

The availability of eight input channels enabled the direct measurement of three physiological variables for each participating couple. These were heart rate, which required two channels (one channel to record the heart pulse and another to calculate heart rate using the interbeat interval), skin conductance level, and finger pulse amplitude. The fourth physiological variable was pulse transmission time to finger. This was obtained by calculating the difference between the heart pulse maximum and the peak of the successive finger pulse wave.

Development of Methodology for Data Recording and Initial Synthesis of Physiological Data

The recording and preparation of sequential physiological data for later bivariate statistical analysis created several unique challenges. Some of these were foreseeable while others emerged as the collection of data progressed. The solution of these challenges soon became a major focus in the research endeavour and evolved into the development of a specific methodology for the collection and synthesis of physiological data for bivariate analysis.

Data storage requirements. The selection of a sampling rate of 200 samples per second for each of the eight channels, in conjunction with recording 60 to 65 min of continuous data for each couple, required approximately 12.5 Megabytes of data storage per couple (without data compression). Computer memory limitations prohibited storage of data for all couples on the computer hard drive and a data file for a single couple was too large for a conventional three and a half inch floppy disk which has a capacity of 1.4 Megabytes. Use of an external Zip™ drive with a storage capacity of 80 Megabytes solved this issue and also enabled backup copies of the raw data for each couple to be made. Later, as the research progressed, a higher capacity computer became available which simplified data handling requirements.

Synthesis of heart rate and skin conductance data into sequential averages. For later bivariate time-series analysis it was required to produce sequential averages for physiological measures during baselines and interaction segments. Initially, 5 s averages were selected. MacLab uses the application program Chart 3.6 to run data collection and analysis. A data pad is an incorporated feature that enables one to calculate some basic statistics on selected channel data. This feature suits standard physiological data handling procedures where one typically compiles the averages of selected sections of data from each participant for use in later statistical analysis. However, for the current research, sequential 5 s averages for each physiological variable were required. One solution was to select each successive 5 s segment of data and use the data pad to compile sequential 5 s averages. This required highly accurate selection of 5 s segments. This selection was found to be difficult and time consuming. Thus, another solution was sought using the macro programming instructions available within chart 3.6. It was identified that a macro was required that could scan a data channel containing a continuous or segmented record of physiological data, and place sequential 5 s averages of the physiological variable on the data pad. Following extensive experimentation a macro was developed that could scan four specific channels simultaneously (i.e., both heart rate channels and both skin conductance channels) and place sequential 5 s averages on the data pad.

Calculation of finger pulse amplitude and the production of sequential data averages. A technique for calculating finger pulse amplitude was already in use at the University of Tasmania. This involved using the *zoom window* feature of chart 3.6 where each successive finger pulse amplitude signal was amplified in the zoom window and, using the cursor, the preceding minimum and the subsequent maximum were identified and recorded. These minimum and maximum levels were later entered as two columns in an Excel spreadsheet and subtracted to derive successive finger pulse amplitude values. This technique was accurate and suitable for small segments of data. However, it was considered unsuitable for continuous data where 60 min of sequential data for each spouse would typically result in the manual recording of between 7000 and 8000 minimum and maximum levels for conversion into finger pulse amplitude values for each couple. Consequently this technique was deemed too time consuming for sequential data and an alternative technique was sought.

Another feature of chart 3.6 is the provision of Computed Functions, one of which enables the calculation of pulse height. Computed functions use the raw data as input and produce a new continuous signal based on the function selected. The computed record may replace the incoming raw data or supplement it by use of another data channel. For example, heart rate was calculated from the raw heart pulse data using the *ratemeter* function and placed on another channel.

The *pulse height* function of chart 3.6 was checked and found to calculate pulse height by identifying each maximum in turn and subtracting each successive minimum from the preceding maximum. This method was inappropriate as finger pulse amplitude is normally calculated by subtracting the preceding minimum from the following maximum. When this feature of chart 3.6 was identified, data for some couples was already recorded. To ensure that the correct value of finger pulse amplitude was calculated for these earlier data records, finger pulse amplitude data records were inverted and pasted to another channel prior to applying the pulse height function. For later data files the finger pulse signal was inverted at input to eliminate this step. The pulse height function was then applied to the inverted finger pulse signal to produce a continuous record of finger pulse amplitude.

For each person, finger pulse amplitude typically varied across the 60 min of physiological recording. To ensure that each peak was detected by the pulse height function for each set of data the following strategy was used. Several threshold settings for the pulse height function were examined to determine if one particular threshold would suit the complete data record for each person. A macro program was written that scanned both finger pulse amplitude data channels and placed sequential 5 s averages of finger pulse amplitude on the data pad. This process was extended when the pulse height function threshold settings were unsuitable for the complete data record. When this occurred the data was divided into segments and the sequential 5 s averages were progressively compiled.

Calculation of pulse transmission time to finger. This calculation was the most complicated to set up. The literature was reviewed to evaluate the range of techniques used to measure pulse transmission time and select one for the current study. Pulse transmission time is the time (in milliseconds) that it takes the heart pulse to reach a distant location in the body. Typically the heart pulse is measured using a standard electrocardiogram technique, which provides the complete heart wave on a beat by beat basis. The arrival of the pulse at a distant site such as the ear, the carotid artery, or finger is recorded by use of a suitable plethysmograph detector. Then the calculation of pulse transmission time is the time difference between a reference point in the R-wave (of the heart rate signal) and a reference point in the peripheral wave.

One of the most popular techniques to measure pulse transmission time was to use the peak of the R-wave as the reference for the heart pulse and either the onset of the peripheral pulse (Hodapp, Heiligtag, & Störmer, 1990; Svebak, Nordby, & Öhman, 1987) or the upstroke of the peripheral pulse (Bunnell 1982; Kaplan, Whitsett, & Robinson 1990; Jennings, 1982; Jennings, Van der Molen, & Brock, 1990; Steptoe, 1976, 1977, 1978; Steptoe & Ross, 1982; Steptoe, Smulyan, & Gribbin, 1976) as the other reference. Location of the reference point on the upstroke of the peripheral pulse was sometimes determined by straight line extrapolation, use of a specific percentage such as 10% of the maximum amplitude of the ascending pulse, or use of the point where the maximum slope occurred on the ascending side of the peripheral pulse.

Another frequently used measurement of pulse transmission time was from the peak of the R-wave to the peak of the peripheral pulse (Bunnell, 1980; Koriath & Lindholm, 1986; Light & Obrist, 1980; Linden & Estrin, 1988; Obrist, Light, McCubbin, Hutcheson, & Hoffer, 1979). Other techniques included: (a) the time from the onset of R-wave to the onset of peripheral pulse (Barry & Mitchell, 1987; Cinciripini & Epstein, 1981; Martin, Epstein, & Cinciripini, 1980; Redman & Dutch, 1983; Redman & Dutch, 1984; Steptoe & Ross, 1981); (b) from the onset of the R-wave to 1/8 of the total amplitude on the upstroke of peripheral pulse (Aylsbery & Marie, 1984; Johnston, Anastasiades, & Wood, 1990; Lo & Johnston, 1984; Marie, Lo, Van Jones, & Johnston, 1984; Toon, Bergel, & Johnston, 1984); (c) the time between the R-wave and the systolic peak of the peripheral pulse (Morell, 1989; Stemmler, 1989); (d) from the onset of R-wave to the peak of the pressure pulse at the earlobe (Öhman, Nordby, & Svebak, 1989); or (e) from the R-wave to the onset of peripheral pulse (Ditto, 1987; Ditto, Miller, & Barr, 1998).

From an evaluation of the equipment used to measure pulse transmission time and the purpose of the research in the various studies, several features became apparent. Most of the earlier studies used hand scoring techniques. Also, the actual measurement of pulse transmission time was frequently constrained by the availability of particular pulse detection circuitry. This restricted the ability to detect specific parts of either the R-wave or the peripheral pulse. For example, Obrist et al. (1979) used the peak of the R-wave to initiate calculation of pulse transmission time because it was reasonably easy to detect in comparison to using another peripheral pulse as reference. They also maintained that using the peak of the peripheral pulse was better because it could be detected more consistently than a fixed point in the ascending limb of the peripheral pulse as recommended by Steptoe et al. (1976). Thus, the repetition by specific authors of the same technique for measuring pulse transmission time may signify an availability of equipment or preference for a specific type of measurement.

Given the improved quality of wave detection circuitry in current psychophysiological recording equipment and the absence of a compelling theoretical argument to select a particular technique, it was decided to measure pulse transmission time from the peak of the R-wave to the peak of the peripheral finger pulse. These peaks in each waveform were relatively easy to detect with the MacLab, and using the peak of the finger pulse waveform included the rise time of the peripheral pulse. This was considered to provide a better indication of changes in cardiac output than measuring to the base of the upstroke of the peripheral pulse.

A two stage process achieved the calculation of pulse transmission time to finger. The first stage was accomplished in the MacLab system and the second stage used an Excel spreadsheet.

For the first stage macros were written that scanned the heart pulse channels to locate each successive peak, then store the peak pulse amplitude and the time it occurred on the data pad. As the heart pulse height, T-wave height, and amount of noise within the heart pulse wave varied both within and between couples, the following strategy was adopted. For each new data set the heart pulse for each participant was checked to determine what threshold value enabled the *find maximum* command in chart 3.6 to locate each successive R-wave and skip over each intervening T-wave. On the basis of this check a set of macros using different threshold settings were progressively compiled. While this approach was found to be optimum, the resulting data files still contained varying amounts of artifacts that were removed when the files were loaded into Excel spreadsheets. A similar process was used to develop macros that would locate the time and value of the finger pulse wave maximums and place these numbers on the data pad. This resulted in data pad files that were saved as four separate text files (two for heart pulse and two for finger pulse), each of which typically contained between four and five thousand records.

For the second stage, the data pad text files were loaded into Excel spreadsheets on an IBM personal computer. Rows were then aligned so that each row contained an R-wave peak followed by its succeeding finger pulse peak. The presence of both the time and value of pulse maximums assisted in identifying the artifacts for removal. Then the data columns were segmented into baseline and interaction phases. Data in excess of the 4 min baselines or the 8 min interaction phases were deleted. Pulse transmission times to finger were then calculated by subtracting the time of the finger pulse wave from the time of the R-wave. Finally, data within each dyad was compared and adjusted as necessary to ensure that for each baseline and interaction phase pulse transmission time to finger commenced within the same 1 s time frame for both the man and the woman.

Production of sequential data averages for pulse transmission time to finger and the preparation of physiological data for bivariate analysis. Levenson and Gottman (1983) used the preceding baseline means and standard deviations to compute *z*-scores (or more accurately, deviation scores from baseline) for each individual during each interaction segment. In this way the sequential physiological data for each interaction segment was *normalised*. From a review of the literature on the Law of Initial Value (LIV; presented later in this chapter), it was determined that the use of residualised change scores was required to control for initial-value dependency in physiological data. The technique proposed by Levenson and Gottman met this requirement and was used for the current research.

Excel spreadsheets were initially used to solve this phase of data preparation for three physiological measures (heart rate, skin conductance level and finger pulse amplitude). This technique was later abandoned for the following reasons. Firstly, it was not automated and required setting up a new spreadsheet for each set of couple data. This practice was not standardised, was sensitive to operator error, and required double checking. Secondly, it became clear that the calculation of sequential averages from the raw data of pulse transmission time to finger was problematic. The difficulty was the number of data points to be included for averaging frequently varied across successive 5 s averaging intervals for each individual (due to basic differences in heart rate). Consequently, the averaging process would need to be done manually, was highly labour intensive, and sensitive to operator error. Finally, flexibility in defining the averaging interval was desirable, as different averaging intervals were likely to impact on the outcome of later data analysis.

It was concluded that standardisation of this phase of data handling would be required to eliminate the difficulties described. To solve this a program specification was written outlining the calculation requirements to produce sequential averages from the raw data of pulse transmission time to finger. Details of how to calculate normalised sequential data sets for each interaction phase were also outlined. The format of the input data file was defined and the required format for the output data file was specified. User definition of averaging intervals was also requested. This flexibility was considered important as later analysis of data could indicate that a change in averaging interval was warranted. The program specification is provided in Appendix A. A computer programmer developed the desired program in conjunction with the author. This program was rigorously tested on an earlier set of test data produced in Excel and used for subsequent data sets. This program provided 24 output data files in the correct format for later bivariate analysis. Each output data file contained the normalised sequential averages for the man and the woman arranged as a single column of data (male data followed by female data). The 24 files arose from the four physiological variables, measured across three interaction segments in which each partner, in turn, led the conversation.

Development of Methodology for the Analysis of Bivariate Data

The desired bivariate analysis procedures were not available within the Statistica™ or SPSS™ statistical packages. Therefore, the bivariate analysis programs developed by Gottman and Williams plus the user's guide to the programs were purchased (Williams & Gottman, 1982). During the setting up and testing of the programs information emerged that led to the development of a methodology for the analysis of bivariate data for the current research.

Initial set up and testing of the Gottman-Williams time-series analysis programs. The Gottman-Williams programs (Williams & Gottman, 1982) were written in FORTRAN IV and originally designed to be run in Disc Operating System (DOS) mode using punch card input. The program instructions were printed out and analysed to determine how best to set up and use the programs. Several file formats were also set up and tested. The outcome of these analyses revealed the following:

(a) the input data file names could be a maximum of eight characters long (which is a DOS limitation); (b) the programs could only run files located in the same directory as the FORTRAN program; (c) it was easier to set up input data files as text files, tab delimited; (d) single column data files were easily read by the programs, whereas other formats (such as double column formats) proved problematic. In addition, the precise format of the FORTRAN instructions required to define the structure of the data files was determined for each available analysis. This ensured that files were read correctly and the analysis programs ran effectively.

Following initial set up of the bivariate analysis programs, each program within the package was tested for correct operation by running the sample sets of data provided in the user's guide. All programs were found to be operating correctly.

Spectral density and lag correlational analysis plots. To run the Gottman-Williams bivariate analysis program (Williams & Gottman, 1982) the user supplies the initial value for the bivariate model. As suggested by Gottman and Ringland (1981) preliminary estimates of this value may be determined from inspection of spectral density plots of the sequential data. The number of clear peaks in the spectral plots is evaluated and doubled to arrive at the first estimate for the required number of terms in the bivariate analysis. The Gottman-Williams time-series bivariate program (Bivar) computes two sets of models. One set provides comparisons from which one may determine how well the second series predicts the first and the other set indicates how well the first series predicts the second. The same starting value (input by the researcher) is used for both sets of models. As each series (one for male physiology and the other for female physiology) can have a different number of peaks in their respective spectral density plots, it is quite legitimate to use different starting values to predict each series. However, after experimentation with several data series, it was found that, in general, use of the same starting value was suitable for the prediction of both series. Consequently, after identifying the number of peaks in the spectral density plots for the man and the woman, the highest number of peaks was doubled to determine the starting value for the analysis. For example, if there were three clear peaks in the data for the man and four clear peaks in the data for the woman then a starting value of eight was used for the analysis.

The Spectral Density feature of SPSS was used with a Tukey-Hamming window of five to provide spectral density plots against frequency for all sequential data. Reduction in the size of the Tukey-Hamming window causes less smoothing to be applied to the spectral density function. Thus, estimation of the number of peaks was problematic and also dependent on the size of the Tukey-Hamming window. After experimentation with several data sets, a Tukey-Hamming window with a width of five was determined as suitable for most data sets, and used as the initial value for all sequential data. If the spectral density plot was quite smooth and it was difficult to discern peaks, the Tukey-Hamming window was systematically reduced to identify whether there were clear peaks in the data. For initial bivariate analysis, inspection of the spectral density plot was used to select the starting values for the analysis. It was found that for some variables the bivariate analysis was not robust and a small change in initial value would alter the result of analysis considerably. It was therefore decided that another method of selecting initial values was required to complement the use of spectral density plots.

After examination of the time-series statistics literature (e.g., Box & Jenkins, 1976; Gottman, 1981) it was determined that the use of lag cross correlational analysis would suit this purpose. Lag correlational analysis, after differencing each series with a lag of one, removes, to some extent, the serial dependency in sequential data and is a useful first order approximation of determining if two series are cross correlated. Differencing each series with lag one means that two new series are estimated. The first term in each new series is the second term of the original series minus the first term in the original series. The second term in the new series is the third term in the original series minus the second term in the original series and so on. The use of cross correlations (with differencing of one) for male and female sequential data, for each physiological parameter, enabled a first order approximation of how well each series predicted the other and at what time lag the cross correlations were highest. Both the presence and time lag of any significant cross correlations provided support for subsequent bivariate analysis results. The time lag at which significant correlations occurred assisted in selecting the number of terms to be included in the bivariate analysis. Thus, selection of initial values for the bivariate analysis involved evaluation of spectral density plots and cross correlational plots for each variable.

The Bivar program (Williams & Gottman, 1982) provides two output summaries of the bivariate analysis. Each summary contains four bivariate models from which to evaluate how well one series predicts the other. The first summary provides information on how well the second series predicts the first series. The second summary provides information on how well the first series predicts the second. Since each set of summary statistics is evaluated the same way the evaluation process for the first set will only be described. The first model in the summary provides a computation of the residual variance of the first series not accounted for by the regression analysis. The number of autoregressive and cross-regressive terms used in the model is equal to the starting value provided by the user. For the second model the program determines the number of autoregressive and cross-regressive terms that provide the best prediction of the target series. This is done by stepping down from the starting value until the optimum solution is found. For example, with a starting value of 10 the first model will contain 10 autoregressive and 10 cross-regressive terms.

The second model may contain, for example, seven autoregressive and four cross-regressive terms after the regression analysis is optimised. The first and second models are compared (using likelihood ratio tests) to determine if the first model is a significantly better predictor of the target series than the second model. If this is the case then the analysis should be run again using a higher starting value until this comparison is non significant. This ensures from the outset that one starts from a model that is a good predictor of the target series and affords some protection against accepting spurious results (e.g., Wagner & Calam, 1988). The third model retains the autoregressive terms from the second model and drops out the cross-regressive terms. A comparison of model two with model three then indicates if the addition of cross-regressive terms significantly improves the prediction of the target series. It is this comparison that indicates if one series is predictable from the other (using cross-regressive terms) above the ability of the target series to predict its future from its own past (using autoregressive terms). The fourth model contains the starting value of autoregressive terms and no cross-regressive terms. Comparison of model three with model four indicates whether the simple addition of autoregressive terms also improves prediction of the target series. If this comparison is significant, then the outcome of the comparison of model two with model three is rejected. Thus, this comparison also provides protection against accepting spurious results when the predictability of the target series can be significantly improved by simply adding terms from its past.

Piloting of New Methodology

It was intended initially to videotape couple interactions as per Levenson and Gottman (1983). The primary purpose of the videotapes was for couples to watch them and do ratings of affect. A secondary purpose was to get independent raters to code empathic interactions between couples. For rating purposes physiological recordings were required to be synchronised with the videotaped couple interactions. After investigation it was identified that a trigger output was available from the video equipment and a trigger input could initiate recording on the MacLab. A circuit was designed that successfully interfaced the two systems. Then a dial for rating of affect was developed using a simple potentiometer circuit that provided a linear relationship between dial position and level of input to the MacLab. As per Levenson and Gottman (1983), 'very negative' was located at zero degrees, 'neutral' at 90 degrees, and 'very positive' at 180 degrees.

Then piloting of couples commenced. To complete the experiment in one session took about 3 hrs. This included answering questionnaires, setting up and testing of physiological measuring devices, 1 hr of couple interactions, and rating the affect in videotapes. After piloting, videotaping of couple interactions was abandoned for the following reasons: (a) examination of videotapes revealed that there were few overt interactions on the videotapes suitable for later coding by independent raters; (b) some couples were making errors in the use of the affective rating device, which indicated that training and testing of couples on a pre-rated video would be appropriate to ensure that the rating device was used correctly; and (c) feedback from couples was that 3 hrs was too taxing and they were reluctant to commit to the alternative of two separate sessions in the laboratory.

The Ubiquitous Law of Initial Value (LIV)

The Law of Initial Value (LIV) is a much debated yet often neglected topic in studies that measure physiological variables. Given the importance attached to physiological measures in the current research, it was considered prudent to assess, if and how, the LIV may affect the results and to determine what strategies were required to ensure that the likely impact of the LIV was negligible.

The LIV has been variously described in the psychophysiological literature as "an obstacle to be circumvented..." (Lacey & Lacey, 1962, p. 1257), "One of the perplexing problems in psychophysiology..." (Hord, Johnson, & Lubin, 1964, p. 79), "...arguably psychophysiology's best-known principle" (Furedy & Scher, 1988, p. 120), and "...a subject of continuing interest for psychophysiologists..." (Jamieson, 1993, p. 233). Originating in the medical sciences, the LIV emerged as an important issue for psychophysiologists following Lacey's (1956) paper in which it was concluded that the LIV had been amply demonstrated for autonomic variables and therefore warranted serious attention by psychophysiologists.

What effects signify the operation of the LIV? Joseph Wilder, the originator of the LIV, defines it as follows:

> The LIV, an empirical-statistical rule, claims that the following is a general rule for the quantitative relation of response and stimulus. Given a standard dose of stimulus and a standard period of measurement the response, that is, the change from the initial (pre-stimulus) level, will tend to be smaller when

> the initial value (IV) is higher; this applies to function-raising stimuli. For function-depressing or function-inhibiting stimuli this negative correlation becomes positive. Furthermore, beyond a certain range of IV's there is an increasing tendency *sometimes* toward absent and *frequently* toward reversed (paradoxic) responses; the higher these extreme IV's the more frequent are the reversals on function-raising stimuli; the lower the IV's the more frequent are the reversals on function-depressing stimuli. (Wilder, 1962, p. 1211)

In this formulation the LIV has an opposite effect on function-raising compared to function-depressing stimuli. Additionally, with high or low initial values close to threshold, a reversal of the 'normal' operation of the LIV would be expected. In other situations LIV effects may be entirely absent. One difficulty posed by the full formulation of the LIV is that a wide range of results could be considered to conform, in some way, to LIV predictions. Consequently, it was not surprising that the full formulation of the LIV was rarely presented in the literature and the definition was usually restricted to the aspect of the LIV that was specific to the research question.

If the LIV operates in a given experimental situation, differences in initial level (within or between groups) may produce differences in outcome that simply reflect the operation of the LIV rather than a treatment or experimental effect. Therefore, appropriate experimental rigour is required to identify and control for this potential confound during data analysis to ensure that outcomes reflect real effects in data.

The LIV: A "law" or a principle? Although Wilder (1962, 1967) was consistent in his view that the LIV is a statistical law, the general consensus in the literature is that the term *principle* is more appropriate. For example, Sternbach

(1966) found sufficient inconsistencies between studies of the LIV to support the position that the LIV be considered a principle. Stern, Ray, and Davis (1980), from their review of the LIV, also preferred the term 'principle' given that the LIV "...is often supported, but it does not hold at all pre-stimulus levels, or for all subjects, or for all ANS measures" (p. 62). Similarly, Andreassi's (1995) detailed review of the LIV supports the proposition that the LIV is best considered a principle.

As discussed by Furedy and Scher (1988), if one considers the LIV as a methodological rule, or "law", then researchers will be less likely to investigate the boundaries of applicability of the LIV. Similarly, alternative explanations for the presence of LIV type effects are less likely to be considered. This can result in research that is merely demonstrational where results are simply reported as being in agreement, or not in agreement, with LIV predictions (e.g., Brandt, 1962; Mock, 1962). Furedy and Scher favour a more investigative approach where the LIV is treated "...as an empirical generalization to be tested in a differentiated manner" (p. 121).

A good example of this approach was provided by Lovallo and his colleagues who, in a series of three studies on cardiovascular reactivity to the cold pressor test (i.e., immersion of an extremity in cold water), considered alternative explanations for the results other than the operation of the LIV. It was tentatively concluded that the results of the first two studies exemplified a homeostatic mechanism and fitted with predictions of the LIV (Lovallo, Parsons, & Holloway, 1973; Lovallo & Zeiner, 1974). The homeostatic argument is that the further physiological measures move away from resting levels, homeostatic mechanisms are invoked that increase activity progressively to return physiological parameters back to normal or near normal levels (e.g., Lacey, 1956). Lovallo and Zeiner (1975) followed up with a more detailed study employing a 3 x 3 Latin square, within subjects design (which they considered more robust than the between subjects design used in the earlier studies), where each subject was tested three times under three room temperature conditions (12 °C, 22 °C, 32 °C). Differential effects were found for pulse wave amplitude (PWA): When resting PWA was small the response to cold pressor was a reversal-vasodilation and when resting PWA was large a reversal-constriction occurred. Equal and significant heart rate increases occurred in response to cold pressor but there was no differential effect of air temperature on heart rate. Also, habituation occurred over the three trials with a breakdown of the initial relationships on trial three. While some of the results in this study were consistent with LIV predictions, Lovallo and Zeiner were reluctant to conclude that the LIV was demonstrated. They decided that there was an interaction of three factors. "These are, the stressor itself which elicits an initial heat retention response in normal conditions, the ongoing level of vascular compensation and sympathetic tonus, and finally the prior history of exposure to the stressor" (p. 505).

The absence of an agreed theoretical framework to investigate the LIV. Although the concept of the LIV has been around for more than six decades a generally accepted theoretical framework, within which the LIV may be thoroughly investigated, has yet to be formulated. The tendency not to seek alternative explanations for LIV effects was supported by the assumption that homeostatic mechanisms produced LIV effects. However, as cautioned by Stern, Ray, and Davis (1980), the belief that homeostatic processes underpin the LIV is an assumption. While some authors have provided alternative theories for the presence of LIV effects (e.g., Hord, Johnson, & Lubin, 1964; Jin, 1992), systematic study has yet to occur to evaluate them.

Theories of the LIV have tended to be unidimensional. Berntson, Cacioppo, and Quigley (1991, 1993) suggested an alternative multidimensional approach. These authors noted that the more traditional theory of reciprocal inhibition between the sympathetic and parasympathetic branches of the autonomic nervous system (where increased activity in one branch was accompanied by decreased activity in the other) frequently proved inadequate to explain contemporary findings for the activity of dually innervated organs, such as the heart. They contended that "It is now clear that the two autonomic branches can vary reciprocally, independently or coactively" (p. 296). A model of autonomic space was developed that enabled these modes of activation to be represented in a three dimensional space. Within this model homeostasis and the LIV were viewed as one aspect of the proposed 'law of dynamic range'. This law took into account sympathetic and parasympathetic boundaries of activation, plus end organ manifestation that is the usual focus of LIV studies. They argued that the focus on end organ responses and the inability to separate out the various components that may constrain end organ response had contributed to the inconsistent history of the LIV.

The later finding that baseline postural manipulations (sitting v standing) were found to have a differential LIV effect for heart period response to a speech-stressor, led to a call for "...a more comprehensive model of autonomic constraints, derived not from empirical induction, but from an understanding of fundamental underlying mechanisms. Such a model could subsume the veridical aspects of the LIV and provide a more useful conception of autonomic constraints" (Berntson, Uchino, & Cacioppo, 1994, p. 209). The application of this model in constructing the autonomic space for the heart response of the rat showed utility (Berntson, Cacioppo, Quigley, & Fabro, 1994). However, less invasive techniques are required for human participants.

To date unidimensional approaches have proved somewhat inadequate to explain the range of results in LIV studies. In contrast, multidimensional approaches provide superior explanatory power and proffer theoretical frameworks that may benefit future explorations of the scope and applicability of the LIV phenomenon. However, studies using a multidimensional approach are scarce.

Detection and removal of LIV effects. To detect the operation of the LIV it is required to determine initial-value dependency in data and demonstrate that the LIV caused the initial-value dependency. Beginning with an initial (pre-stimulus) value X, and a final (post-stimulus) value Y, the response to the experimental stimulus may be represented by the difference score $D = Y - X$. Using these basic variables several approaches were suggested to test for initial-value dependency. Heath and Oken (1962) used the correlation of initial value with the difference score (r_{xd}) to test initial-value dependency for function-raising stimuli and the correlation of the post-stimulus level with the difference score (r_{yd}) for function-decreasing stimuli. Block and Bridger (1962) computed the least squares regression line of D on X (b_{dx}) and, when the slope was less than unity, initial-value dependency was considered to be demonstrated (for function-raising stimuli). In contrast, Hord, Johnson, and Lubin (1964) used the least squares regression line of post-stimulus on pre-stimulus levels (b_{yx}).

Benjamin (1967) examined these various correlational methods and concluded that, if only one was to be chosen to detect initial-value dependency, then the correlation r_{xd} was favoured above r_{yd}, b_{dx}, or b_{yx} on the basis of least squares methodology.

Once initial-value dependency is identified it is then required to demonstrate that the LIV caused it. Several difficulties arise as initial-value dependency may also represent a statistical artifact. For example, Surwillo and Arenberg (1965) cautioned that the slope of the regression line (b_{yx}) was susceptible to regression towards the mean. It has also been identified that r_{xd} will be negative if the variances are unequal and satisfy the relationship $s_x / s_y > r_{xy}$, and positive if $s_x / s_y < r_{xy}$ (e.g., Lacey & Lacey, 1962; Myrtek & Foerster, 1986a). Similarly, Jamieson and Howk (1992) and Jamieson (1993) identified, in computer based simulation studies, four factors (variance change, floor or ceiling effects, reactivity, and skewness) which produced outcomes resembling LIV effects via changes in variance while measurement error produced LIV type effects through regression towards the mean. Jamieson (1993) noted that since floor and ceiling effects (typically real LIV effects) were similar to a decreasing variance effect, it was unclear how these could be separated. Similarly, any variance decreasing factor that resulted in skewing the distribution opposite to its tail could be confused with a real initial-value dependency or an LIV effect.

Despite these difficulties several techniques have been proposed to help identify whether initial-value dependency is due to the operation of the LIV or a statistical artifact. For example, Myrtek and Foerster (1986a) outline an approach to identify the operation of the LIV using the formula proposed by Kendall and Stuart (1967) to calculate the slope of the regression line (modified b_{yx}). Also, Geenen and Van de Vijver (1993) identified that when the LIV was operating a negative r_{dx} was accompanied by a decrease in variance between pre- and post-stimulus levels. However, this effect was absent when $-r_{dx}$ was due to measurement error alone. On the basis of these findings they suggested that a correlation between pre- and post-stimulus variances would enable one to determine if $-r_{dx}$ was due to the LIV or measurement error. While these techniques have limitations, it can be concluded that the use of r_{dx} and modified b_{yx} currently provide the best available test for initial-value dependency and the operation of the LIV.

After the presence of initial-value dependency is demonstrated, the next issue is whether initial-value dependency is viewed as a nuisance to be removed or retained as part of the research design. As discussed by Jin (1992), when the LIV is the actual purpose of study, to create a score that is independent of initial values may result in a loss of critical information. Consequently, the elimination of LIV effects remains a research choice.

Several techniques for the removal of initial-value dependency and LIV effects have been proposed. For example, Lacey (1956) suggested the use of the Autonomic Lability Score (ALS) to statistically remove the LIV in order to evaluate experimental outcomes independent of initial values. The ALS expresses individual responses in terms of frequency distributions with means of 50 and standard deviations of 10. In Lacey and Lacey's (1962) study the ALS provided improved consistency, reliability, and interpretation of results in comparison to the use of algebraic or percentage change scores to evaluate experimental outcomes.

Benjamin (1967) concurred that use of the ALS or another variation of analysis of covariance was preferred when creating a score independent of initial levels. Lykken (1968) disagreed with this position and argued that, *because* the ALS removed important correlations in the data, its use was inappropriate. Lykken proposed that individual scores, in response to a stimulus, be range adjusted on the basis of the minimum and maximum response available to each individual for each physiological measure. The invasive techniques suggested to determine these limits might partly explain why this approach is rarely mentioned in the literature.

Myrtek and Foerster (1986a) proposed the use of Kendall and Stuart's (1967) formula to estimate the slope of the regression line (i.e., modified b_{yx}), remove initial-value dependency, and test for the presence of LIV effects. This estimate assumes that the error variances for pre-stimulus (*X*) and post-stimulus levels (*Y*) are equal. Whenever this estimate of the slope is significantly less than unity LIV is indicated and anti-LIV is indicated when it is significantly greater than unity. In their study of 125 males tested under four conditions (cold pressor test, breath holding, reaction time, and a digit series test), when initial-value dependency was controlled for, 15 variables exhibited anti-LIV and only one result (electroencephalogram during the digit series test) was as predicted by the LIV. Cleary (1986) questioned if Myrtek and Foerster's (1986a) results would change if the error variances for *X* and *Y* were known rather than assumed to be equal. To examine this, Cleary estimated error variances for some of the Myrtek and Foerster data and calculated the slope of the regression line to be less than unity. This result was opposite to Myrtek and Foerster's anti-LIV findings. However, when Myrtek and Foerster (1986b) reanalysed their data in accordance with Cleary's suggestion, the earlier result of anti-LIV still held, although the value of the slope of the regression line was reduced.

Llabre, Spitzer, Saab, Ironson, and Schneiderman (1991) challenged the emerging consensus that some form of residualised change score (e.g., ALS) was more suitable to examine change than the use of delta - a simple gain score (e.g., $D = Y - X$, where *X* is initial level and *Y* is the response level). They combined data from two experiments and computed estimates of reliability for residualised and delta scores. Both scores were found to have equivalent moderate to high reliabilities across seven tasks and three physiological variables. The authors concluded that the delta gain score was a suitable measure of change. However, it should be noted that in this study initial-value dependency was not evident in data. Therefore, delta was demonstrated to be an effective measure of change in the absence of initial-value dependency.

Jin (1992) favoured Myrtek and Foerster's (1986a) approach when dependence on initial values was demonstrated by checking that r_{xy} was significant *and* the difference score ($D = Y - X$) was significantly different from zero. This suggestion was consistent with the findings of Llabre et al. (1991).

Jamieson (1995), in a computer simulation study, assessed the relative merits of the use of gain scores and analysis of covariance (ANCOVA) to assess change across four conditions - ceiling and floor effects, skew, variance change from pretest to posttest, and measurement error. The results for ceiling, skew, and variance change conditions were that, as r_{dx} became more negative, gain scores became less and less effective at detecting change. In contrast, ANCOVA was unaffected and therefore superior to gain scores at detecting change for these three conditions. For the measurement error condition neither approach showed superiority at detecting change. Jamieson cautioned that the existence of $-r_{dx}$ alone did not invalidate the use of gain scores and recommended the use of Geenen and Van de Vijver's (1993) variance test to adjudicate whether measurement error or an LIV type effect produced the negative r_{dx} for a given data set.

Goldwater (1978) suggested a departure from correlational analysis and advocated an experimental design approach to check for LIV effects. In this study two levels of relaxation and two levels of exercise were used. Responses were measured on six physiological variables to a tone-cued digit task, across four test trials, for 48 male subjects. This study demonstrated LIV effects indicated by a tendency for a reduction in magnitude of response when the initial level was increased by physical exercise for heart rate, skin conductance, and blood pulse volume. The finding for skin conductance was opposite to the majority of earlier findings for this measure. Goldwater acknowledged this discrepancy and suggested additional studies to examine if these differences could be reconciled.

In summary, the body of evidence suggests that some form of residualised change score such as the ALS or use of the modified b_{yx} are appropriate to remove initial-value dependency and test for the presence of the LIV. Similarly, to test for group differences independent of initial-value dependency, analysis of residualised change scores, modified b_{yx} scores, or ANCOVA is indicated. The use of algebraic or percentage change scores are generally unsuitable unless there is little evidence of initial-value dependency in the data. The experimental design approach suggested by Goldwater (1978) requires further investigation to evaluate the utility of this technique.

The LIV versus response stereotypy. Block and Bridger (1962), considered that the emphasis on the LIV was misplaced and that response stereotypy (i.e., the ability of a stimulus to produce a consistent response) was a more important issue in psychophysiology. Their study of response to electric shocks provided partial support for this position. Similarly, Lacey and Lacey (1962) emphasised how their results for the cold pressor showed consistency in producing a particular level of response when baseline levels exhibited high levels of variability. In Lovallo and Zeiner's (1975) study of responses to cold pressor under different conditions of air temperature the results for heart rate supported response stereotypy. Also, Llabre et al. (1991) noted that "...the reliability of measures of reactivity may depend upon the behavioral challenge used and the physiological parameter assessed" (p. 709).

Evaluation of the LIV and response stereotypy are not mutually exclusive and checks for the presence of both may be undertaken for a given set of data (e.g., Fahrenberg, Foerster, & Wilmers, 1995; Lacey & Lacey, 1962). The issue of response stereotypy highlights stimulus characteristics and the importance of a particular stimulus or treatment being capable of producing a response in the variables to be measured in order that meaningful comparisons can be made.

The LIV and specific physiological measures. In Sternbach's (1966) review, LIV type effects were found for measures of heart rate, respiration, and peripheral blood flow, but not for skin conductance. Stern, Ray, and Davis (1980) noted that LIV predictions were generally supported for heart rate and skin resistance measures but not for skin conductance and that a few studies for blood pressure and respiration also supported the LIV. Andreassi (1995), in a more detailed review, generally corroborated the findings of earlier reviewers. However, in addition to the earlier parameters, positive results were added for pupil dilation, T-wave amplitude, finger vascular activity, and finger skin temperature. How initial-value dependency was determined in individual studies was not examined in these reviews. This raises doubt regarding the validity of the findings for the LIV.

Since 1994 few studies have explicitly examined the LIV with regard to initial-value dependency. An exception was Fahrenberg, Foerster, and Wilmers (1995) who examined blood pressure and heart rate response of 136 subjects under conditions of mental load and physical exercise. From the total sample two sub-groups of 42 subjects with normal and elevated blood pressure were formed who were matched on age, weight, circumference of upper arm, alcohol use, cigarette consumption, medical health, and self reported physical fitness. For analysis, three response scores were derived: a simple change score $D = Y - X$; the ALS; and 'true' change T scores derived from the model proposed by Myrtek and Foerster (1986a). The simple change score was sample independent while the other two scores were sample dependent. The elevated blood pressure group exhibited higher responsiveness in heart rate, systolic and diastolic blood pressure measures across experimental tasks. Correlation and regression analysis revealed that these differences were primarily due to differences in baseline that persisted throughout tasks. Responsiveness was most evident in the true change T score measure but not in the more conventional difference score (D) or ALS. The principal test for initial-value dependency was the modified slope of the regression line as proposed by Myrtek and Foerster (1986a). When all 136 subjects were included for analysis, positive initial-value dependency was found for systolic blood pressure under all four reported conditions, for diastolic blood pressure under three conditions and for heart rate under two of the four conditions. For the normal and elevated blood pressure groups positive initial-value dependency also emerged. That is, the higher the pre-task level the greater the response to the task. The authors noted that this result was at variance with Wilder's (1967) definition of the LIV (where, as the pre-task levels increase, the response levels would be expected to decrease) and some of the earlier findings in the literature, but consistent with some results from Myrtek and Foerster (1986a). Further studies using suitable analytic techniques such as those proposed by Fahrenberg et al. (1995) are required to evaluate which physiological parameters conform to LIV predictions.

The LIV and the current research. The LIV literature highlights the presence of initial-value dependency in physiological systems and the effects this may have on physiological data. If initial-value dependency is ignored in experiments that measure physiological parameters this may lead to incorrect interpretation of results. In psychophysiological research some control for initial-value dependency is provided by the use of baseline measurements prior to experimental manipulations. However, differences in baseline levels within or between groups may result in outcomes that reflect these baseline differences rather than an experimental effect. Additionally, for individuals who have different levels of physiological response at baseline, the LIV is expected to affect differentially their range of response to subsequent experimental manipulations. The use of residualised change scores provides control for the likely effects on outcome data for these differences in baseline levels independent of why they occurred.

Consequently, for the primary analysis in the current research, residualised change scores were used to provide control for initial-value dependency and improve interpretation of results between groups. The use of residualised change scores also enabled comparison of results across physiological parameters.

Another issue that emerged from this review of the LIV was the importance of ensuring that an experimental stimulus is capable of producing a reliable physiological response (i.e., response stereotypy). This was considered relevant to the current research and a check that the experimental manipulation reliably altered physiological responses from preceding baselines was included as part of the analysis.

Summary

In this chapter the development of methodology for the synthesis and analysis of sequential dyadic data was described. For the current research the production of sequential 5 s averages for each physiological parameter was required. It was then required to transform these sequential 5 s averages into sequential residualised change scores for later bivariate time-series analysis. The required data synthesis was achieved by the development of a series of macro programs for the MacLab system and a program to produce sequential residualised change scores.

The next phase of methodological development involved designing a standardised approach for the analysis of bivariate data. To achieve this, information was integrated from the general literature on time-series statistics and the specific literature on the analysis of sequential dyadic data. This was followed by testing the techniques on sample sets of data using the Gottman-Williams time-series analysis programs (Williams & Gottman, 1982).

Following the development of affective rating dials and circuitry to synchronise video recording equipment with the physiological recording equipment the methodology was piloted. This resulted in some modifications in the methodology for the subsequent research.

The chapter concludes with a review of the LIV literature. This review outlines the rationale for the use of residualised change scores in the current research to provide control for initial-value dependency in physiological data.

Chapter 6

The Effect of Empathic Listening on Physiological Linkage

Chapter 6

The Effect of Empathic Listening on Physiological Linkage

The present research examined whether physiological linkage would occur during the expression of neutral, positive, and negative affect in dyadic couple interactions when each partner was specifically asked to engage in empathic listening. The assertion of Levenson and Ruef (1992) that physiological linkage may signify the feeling component of empathy was assessed. The support provided for the three stage model of empathy developed in chapter 2 was also assessed.

Application of the Proposed Three Stage Model of Empathy to the Current Research

Use of the three stage model of the empathic process provided a framework to systematically examine the literature and identify which components of empathy were measured in a given study. The model was also easily adapted to the study of dyadic interactions, simplified the process of framing the research question, and assisted in the selection of appropriate measures for the components of empathy used in the current research. Finally, the structure of the model indicated the expected relationships between the components of empathy, which guided the statistical analyses.

It was initially intended that all elements of the proposed three stage model of empathy would be tested in the current research. When the methodology was finalised after piloting, it was identified that the second stage of the model became largely redundant as compassionate responding was manipulated experimentally.

Thus, for the current research the first and the third stage of the model were used with specific focus on the feeling component of empathy.

Selection of Participants

Married or de facto couples were favoured over other dyads (e.g., strangers or client-therapist) as couples who have lived together for several years were likely to have achieved a relatively detailed interpersonal knowledge. This was expected to provide a good basis for the analysis of the physiology that accompanies couple interactions (Notarius & Herrick, 1989). Also, couples in longer term relationships were likely to possess adequate knowledge of their partner's history and style of interaction. This would enhance their ability to engage in empathic listening via role-taking or perspective-taking behaviour (Oliver, 1975; Smither, 1977). In addition, detailed interpersonal knowledge would assist spouses in decoding subtle ongoing verbal and non-verbal cues in their partner's communications. The selection of only non-distressed couples for participation was expected to reduce the reciprocity of negative affect found by Levenson and Gottman (1983) for distressed couples.

Methodological Refinements and Hypotheses

To facilitate empathic listening in the present study each partner, in turn, was asked to (a) listen to a story told by his or her spouse, and (b) to engage in perspective-taking while listening. It was considered that this empathic listening task was similar to Levenson and Ruef's (1992) affective rating task and likely to produce similar results for physiological linkage between spouses. Thus, it was hypothesised that physiological linkage would be predictive of perspective-taking. It was also anticipated that the perspective-taking abilities of spouses would be positively correlated with levels of marital satisfaction. Finally, to test the assertion of Levenson and Ruef that physiological linkage represents the feeling component of empathy, it was hypothesised that physiological linkage would be predictive of levels of marital satisfaction. The regulation of turn-taking, in the current research, was expected to provide some control for dominance patterns that may have been present in some relationships. Turn-taking would also enable one to examine whether the physiology of the person telling the story predominantly predicted the physiology of the designated listener.

Three interaction segments were used to assess whether physiological linkage was a robust phenomenon across affective states when couples engaged in empathic listening. These were the neutral and conflict interaction segments as used by Levenson and Gottman (1983) with the addition of a positive interaction segment. This addition enabled examination of three ranges of affect. As naturalistic interactions would be restricted by the proposed changes in methodology, it was decided that in the conflict segment each partner would relate to their spouse a conflict with a third party rather than attempt to resolve an interpersonal conflict. The affective rating dial used in the earlier studies was omitted as affective content was largely regulated by experimental manipulation. The absence of the rating dial would restrict somewhat the interpretation of results. This limitation was considered acceptable as the primary focus was to examine how robust physiological linkage was across affective states when couples engaged in perspective-taking.

In summary, for the current study it was hypothesised that:

1. The physiology of the listener would follow the physiology of the speaker during all three discussion segments.
2. Physiological linkage would be predictive of perspective-taking.
3. Physiological linkage would be predictive of marital satisfaction.

4. Measures of perspective-taking would be positively correlated with measures of marital satisfaction.

Method

Participants

Twenty couples, either married or in de facto relationships for more than 2 years, participated in the study. Couples were recruited via advertisements at the University of Tasmania and from a local agency that specialises in relationship counselling. First year Psychology students who participated received partial course credit. Other participating couples received $A30 to offset travelling or child care expenses. Couples were screened using marital satisfaction questionnaires to ensure that only those in non-distressed relationships were selected.

Apparatus

An eight channel MacLab with a Power Macintosh 7300/180 computer was used to collect physiological data. A sampling rate of 200 samples per second was used on all channels. After initial recording of couple data, the MacLab was programmed to produce sequential 5 s averages of the following physiological measures - heart rate (HR) using the interbeat interval, finger pulse amplitude (FPA) using the pulse maximum minus the preceding trough minimum, and skin conductance level (SCL). Pulse transmission time to finger (PTT) was calculated in the following way. Programs were written to scan the heart pulse of each spouse and create a data file containing the time and value of the peak of each successive R-wave. Programs were also written to scan the FPA channels to record the value of each successive peak and the time it occurred. These data files were downloaded into an Excel spreadsheet where the times from the peak of the R-wave to the peak of the next FPA pulse were calculated. These sequential PTTs were input to another program that was developed to produce sequential 5 s averages for the PTTs.

Measures

Four physiological measures were taken - HR, FPA, SCL and PTT. Two measures of marital satisfaction were used - the Kansas Marital Satisfaction Scale (KMSS; Schumm et al., 1986) and the Quality of Marriage Index (QMI; Norton, 1983). These measures were selected because they provide a global measure of marital satisfaction. As discussed by Fincham and Bradbury (1987), global measures such as the KMSS and the QMI "...do not confound description of the marriage with its evaluation" (p. 799). In contrast, traditional measures such as the Locke-Wallace Short Marital Adjustment Test (LWMAT; Locke & Wallace, 1959), the Dyadic Adjustment Scale (DAS; Spanier, 1976), and the Marital Satisfaction Inventory (MSI; Snyder, 1979) contain additional descriptive information about the marital relationship. While this descriptive information is valuable from a therapeutic perspective, measures such as the QMI and the KMSS are better suited for research purposes even though there is a paucity of research on the validity of the QMI scale (Sabatelli, 1988). For the current research the first five questions of the QMI were used. The sixth item was omitted as a 10-point scale was used for this question while a 7-point scale was used for the other questions. It was considered that this differential weighting was inappropriate. Also, the sixth item was an overall assessment of marital satisfaction and largely redundant as specific areas of marital satisfaction were assessed in the first five questions. In contrast, the KMSS had good internal consistency, test-retest reliability, and validity (e.g., Canfield, Schumm, Swihart, & Eggerichs, 1990; Grover, Paff-Bergen, Russell, & Schumm, 1984; JaJeong, Bollman, & Schumm, 1992; Mitchell, Newell, & Schumm, 1983; Schectman, Bergen, Schumm, & Bugaighis, 1985; Schumm et al., 1985; Schumm, Nichols, Schectman, & Grigsby, 1983; Schumm, Scanlon, Crow, Green, & Buckler, 1983; Schumm & Silliman, 1996).

The perspective-taking measures were the Self Dyadic Perspective-Taking Scale (SDPT) and Other Dyadic Perspective-Taking Scale (ODPT; Long, 1990). From a review of the literature the SDPT and the ODPT were the only instruments found that specifically measured perspective-taking within the context of a relationship. For information on the construction, reliability, and validity of these two questionnaires see Long (1990) and Long and Andrews (1990). The SDPT is a self report measure of how well spouses perceive themselves to engage in perspective-taking while the ODPT asks each spouse to rate their perception of the extent to which their partner engages in perspective-taking. The SDPT and ODPT measures contain two subscales: (a) the Strategies subscale, which assesses the strategies used to understand a partner's perspective (e.g., cognitive role-taking); and (b) the Cognizance subscale, which represents a more global awareness and understanding of a partner's thoughts and feelings. The questionnaires and other protocols used for this research are provided in Appendix B.

Procedure

Prior to arrival at the laboratory couples were asked to think of three stories they could tell their partner: (a) a *boring* or *neutral* story; (b) a *happy* story; and (c) a story involving a *conflict* with a third party. On arrival the experimenter checked if each partner had decided on their topics and provided assistance in selecting topics as required. Marital satisfaction questionnaires (KMSS, QMI) and perspective-taking instruments (SDPT, ODPT) were administered. Following a discussion of the experimental procedure physiological measurement devices were fitted and tested for each couple using standard procedures. SCL was measured from the second phalange of the first and third fingers of the non-dominant hand (Stern, Ray, & Davis, 1980). FPA was measured from the finger tip of the middle finger of the non-dominant hand using a plethysmograph sensor. HR was recorded using axillary placement of electrodes on the ribcage (see Andreassi, 1995, p. 224) with the reference electrode placed on the mastoid process behind the left or right ear.

Continuous physiological readings were taken throughout each of the three interaction segments. All interaction segments were preceded by a 4 min baseline phase in which couples were requested to relax and be silent. The sequence of interactions was arranged in the following way. All couples started by taking turns at telling each other a neutral or boring story. The second and third interaction segments (happy and conflict) were counterbalanced across couples. Each story lasted 8 min with start and completion cued by the experimenter via a two-way communication system. Couples were instructed that when they were in the role of listener their task was to listen carefully to their partner, try to understand as best they could their partner's perspective, and clarify any information that was unclear to them.

Results

Marital Satisfaction

The average length of relationship for couples who participated in this study was 13.20 years ($SD = 6.41$). Men and women reported equivalent and high levels of marital satisfaction on each of the questionnaires. The means for the KMSS were 19.05 ($SD = 2.56$) for men and 18.35 ($SD = 2.76$) for women out of a possible maximum of 21. The means for the QMI were 32.95 ($SD = 3.60$) for men and 31.63 ($SD = 4.60$) for women out of a possible maximum of 35. These results indicated that the sample comprised couples in non-distressed relationships. Also, the marital satisfaction measures were highly correlated, $r = .89$, $p < .001$.

Physiological Data Reduction and the Preliminary Analysis of Bivariate Data[a]

Physiological data reduction and preliminary bivariate analysis generally followed the techniques outlined by Levenson and Gottman (1983). These techniques involved the computation of residualised change scores for each physiological variable. As discussed in chapter 5 the use of residualised change scores provides protection from initial-value dependency in data and the operation of the LIV. In this section a brief description of the data reduction and bivariate analysis techniques will be provided. For more detail see chapter 5.

Separate sequential 5 s averages were computed for each partner on each of the four physiological variables (HR, FPA, SCL, and PTT) for all baseline and interaction segments. Baseline means and standard deviations were then calculated for each partner. The preceding baseline means and standard deviations were used to compute *z*-scores (or deviation scores from baseline) for each partner during each interaction. In this way the sequential data for each partner during each 8 min interaction were normalised. This resulted in two pairs of normalised data sets for each physiological variable in each interaction. For example, in the *happy* interaction one set of data resulted from the woman telling the story and the man listening to the story (woman lead and man follows) whereas the other set of data resulted from the man leading and the woman following. As discussed in chapter 5, the use of residualised change scores provided control for initial-value dependency.

Each paired data set of sequential *z*-scores was checked for stationarity and corrected as required using the series differencing techniques outlined by Gottman and Ringland (1981). When differencing failed to produce stationarity (for the man and the woman) each series was inspected and terms were omitted from the start, the end, or both the start and the end of both series (from 5 to a maximum of 20 terms) and differencing was used again. If several variations of reducing terms, followed by differencing each series, failed to produce stationarity then bivariate time-series analysis was not undertaken and zero was assigned for the paired data set.

The Williams and Gottman (1982) bivariate time-series analysis program was then used to analyse each set of paired data. This analysis provided a measure of how well the physiological response of each partner predicted the other partner's response pattern (i.e., physiological linkage). This resulted in two sets of data comprising eight pairs of *z*-scores for each interaction segment. One set of data resulted from the man leading the interaction and the other from the woman leading the interaction. Within each set of data one *z*-score indicated how well the woman's response pattern predicted the variance in the man's response pattern (controlling for the autocorrelation within the man's response pattern). The other *z*-score indicated how well the man's response pattern predicted the variance in the woman's response pattern (controlling for the autocorrelation within the woman's pattern). For all data the starting value for the autoregressive and cross regressive model was 10. Additionally, starting values of 12 and 8 were used to evaluate whether the initial analysis was robust. In general, the time-series bivariate solution for a starting value of 10 was accepted unless the spectral density plot or lag cross correlation plot (with differencing of one) indicated that other starting values were more suitable for the model.

Each time-series bivariate analysis was checked for stability. If the analysis was considered unstable it was assigned zero. That is, when the starting value was deemed appropriate from the spectral density plots and a change in starting value of plus or minus one produced a considerable change in results or a reversal in the direction of prediction, the analysis was considered to be unstable. Also, when comparing the four models provided as part of the program output, if the comparison of model one with two or model three with model four was significant, then a predictive value of zero was assigned (see chapter 5 for further discussion). If, however, the result of the analysis using a starting value of 10 approached significance, then starting values of 9 and 11 were also checked, and if these achieved significance, they were selected.

During the measurement and preliminary analysis of skin conductance data, several difficulties were noted that led to the omission of skin conductance from further analysis. These difficulties included skin conductance data moving out of the range of the measuring equipment (i.e., plus or minus 10 μmho from the initial baseline setting) during discussion segments. In the early stages of data collection this led to the loss of skin conductance during all discussion segments for one couple and during some discussion segments for two other couples. The large shifts in skin conductance were initially considered to be due to insufficient time available for the conductance gel to reach finger temperature prior to commencing physiological recording. To correct for this, skin conductance was the first physiological measure to be set up for later participants so that 15 to 20 min were available for this parameter to stabilise prior to commencing measurement. However, despite this methodological adjustment, skin conductance had to be reset for several couples on at least one occasion during or between interaction segments to keep the parameter within the range of the measuring equipment. Also, for some couples, by the end of the hour of measurement, the conductive gel had evaporated or been absorbed into the skin.

Subsequent examination of the resulting skin conductance data indicated that for several couples there was a slow increase in skin conductance across interaction segments. This may have been due to temperature adjustment followed by evaporation of conductive gel. For other couples skin conductance data was very stable for at least one partner across segments. The outcome was that high cross correlations regularly occurred in the data and these were artifacts rather than the outcome of couple interactions. It was considered that these factors contributed to 216 of the 220 available segments of the skin conductance data failing the test for stationarity. The subsequent differencing of data series to correct for failure of stationarity frequently produced data series where all values were less than one. This in turn generally resulted in instability in bivariate analysis where changing the starting value of the analysis by one or two, produced highly variable outcomes. Consequently, it was decided to exclude skin conductance from further analysis.

After the exclusion of SCL data, 36 (out of 360) bivariate time-series analyses for HR, FPA, or PTT failed stationarity and were assigned to zero. As discussed, some data series required a reduction in terms to achieve stationarity. This produced 43 paired data sets (out of 360) which contained less than 80 terms in each series. The loss of terms required to retain these data sets was considered acceptable, although bivariate effects for these series were expected to be more difficult to detect (Gottman & Ringland, 1981). The remaining paired data sets had an average of 89 points per series, which compared favourably with Levenson and Gottman's (1983) use of 90 points per data series.

The subsequent bivariate time-series analysis resulted in 20 sets of data for HR, FPA, and PTT for further evaluation and analysis. For tests of statistical significance an alpha level of $p = .05$ was used throughout.

Does the Physiology of the Principal Speaker Predict the Physiology of the Designated Listener?

The hypothesis that the physiology of the person leading the discussion would, on average, predict the physiology of their partner was tested in two ways. First, significant results of bivariate analysis for the three physiological measures for each discussion were analysed. This was followed by repeated measures ANOVAs for all bivariate linkage scores, independent of whether the bivariate analysis was significant. The value of the second analysis was that the strength of physiological linkage was assessed. This was expected to provide additional insight into the results of the first analysis where the strength of association was not assessed.

Percentage of physiological linkage during couple discussions. The Williams and Gottman (1982) bivariate time-series analysis program provided *z*-score outputs for each analysis of paired data sets for each couple. Scores with statistically significant levels of physiological linkage present ($zs > 1.96$) were compiled to examine basic linkage patterns. That is, only bivariate scores where either male or female physiology significantly predicted their partner's response were used. The overall result was that, on average, the physiology of the designated speaker significantly predicted the physiology of the listener for 40% of the physiological variables. The breakdown across topic was 38% in the neutral interaction segment, 42% in the happy segment, and 41% in the conflict segment. In contrast, the physiology of the listener predicted the physiology of the designated speaker for 23% of the physiological variables, with a breakdown of 20% during neutral, 23% in happy, and 27% during conflictual discussions. A further breakdown of this data across gender is presented in Table 1. Also included in Table 1 are bidirectional linkage figures that indicate how often both male and female patterns of physiology predicted their partner's physiology in the same segment. That is, when male physiology significantly predicted female physiology, at the same time female physiology significantly predicted male physiological patterns. A 3 x 2 (Topic x Lead) repeated measures ANOVA on the bidirectional percentage scores resulted in no significant main effects or interactions.

In summary, Table 1 shows the most frequent result was the physiology of the person leading the conversation predicted the physiology of the listener. This result was in the predicted direction and occurred for up to 47% of physiological variables. However, for up to 28% of physiological variables the physiology of the listener significantly predicted the physiology of the speaker. This result was opposite to prediction. Nonetheless, it is important to note that this second result was moderated by the presence of bidirectional linkage. For example, when the woman led the conversation during conflict the highest percentage of physiological variables that resulted in physiological linkage occurred across all categories (see the last row of Table 1). However, when the bidirectional linkage of 17% is considered, then only 11% (i.e., 28% minus 17%) of physiological variables resulted in physiological linkage that was opposite to prediction for this particular discussion segment. This moderating influence of bidirectional linkage was quite substantial for all discussion segments.

Table 1

The Percentage of Physiological Variables That Resulted in Significant Physiological Linkage Across Topics and Gender

Condition	Type of linkage		
	Listener follows designated speaker	Designated speaker follows listener	Bidirectional
Man leads discussion			
Neutral	37%	22%	12%
Happy	40%	23%	15%
Conflict	35%	25%	10%
Woman leads discussion			
Neutral	40%	18%	13%
Happy	43%	22%	8%
Conflict	47%	28%	17%

To examine if the patterns suggested by Table 1 were significant, percentage scores of significant linkage were compiled for each spouse for each discussion, for male and female lead, across male and female predict. A Topic x Lead x Predict (3 x 2 x 2) repeated measures ANOVA with Greenhouse-Geisser correction (as recommended by Vasey and Thayer, 1987, to provide protection against sphericity in data when there is low *N* in comparison to the number of factors and levels in the analysis) resulted in no significant main effects. Thus, the percentage of variables for which significant physiological linkage occurred, where the listener followed the speaker, was equivalent for men and women across all three discussion topics. A single significant interaction occurred for Lead x Predict, $F(1, 19) = 40.80$, $p < .001$. Analysis of simple-effects (using two-tailed *t* tests) indicated that this was a fully crossed interaction (all *p*s < .05). The physiology of the person leading the discussion predicted their partner's physiology significantly better than their partner's physiology predicted their physiology.

Analysis within each topic, using Greenhouse-Geisser correction, indicated that the Lead x Predict interaction was the only significant result for all three topics. During the neutral segment the result for Lead x Predict was $F(1, 19) = 10.04$, $p = .005$; for the happy segment Lead x Predict was $F(1, 19) = 13.77$, $p = .001$; and for conflict $F(1, 19) = 10.34$, $p = .004$. Analysis of the Lead x Predict interaction for each topic (using two-tailed *t*-tests) revealed that a fully crossed interaction occurred during the happy segment only (all *p*s < .05), three of the four post hoc comparisons were significant for the neutral segment (*p*s < .05), and two were significant for the conflict discussion segment (*p*s < .05).

Overall, there was a high level of consistency in results for physiological linkage across topics. For five of the six discussion segments, the physiology of the person who was leading the discussion predicted the physiology of the person listening.

The strength of physiological linkage during couple discussions. To examine the patterns for the *strength* of physiological linkage all the *z*-score values of the Williams and Gottman (1982) bivariate time-series analysis program were compiled. All bivariate physiological linkage *z*-scores for men and women were used independent of whether they were significant or not. Three outliers were identified (greater than three *SD*s from the mean) and replaced with the variable means. A repeated measures ANOVA was performed with Greenhouse-Geisser correction. The repeated measures were: (a) topic with three levels - neutral, happy, conflict; (b) lead with two levels - male lead, female lead; (c) predict with two levels - how well male physiology predicted female physiology and how well female physiology predicted male physiology; and (d) physiology with three levels - HR, FPA, PTT. The results for Topic x Lead x Predict x Physiology (3 x 2 x 2 x 3) indicated that there were no significant main effects, and one significant interaction of Lead x Predict, $F(1, 19) = 37.35, p < .001$.

The Lead x Predict interaction is presented in Figure 2. Analysis of simple effects (using two-tailed *t* tests) indicated that this was a fully crossed interaction. When the woman led the conversation her physiology predicted her partner's physiology significantly better than her partner's physiology predicted her physiology, $p < .001$. Similarly, when the man led the conversation his physiology predicted his partner's physiology significantly better than his partner's physiology predicted his physiology, $p = .003$. Additionally, female physiology predicted male physiology significantly better when the woman led the conversation than when her partner led the conversation, $p < .001$. Similarly, male physiology predicted female physiology significantly better when the man led the conversation than when his partner led the conversation, $p = .005$.

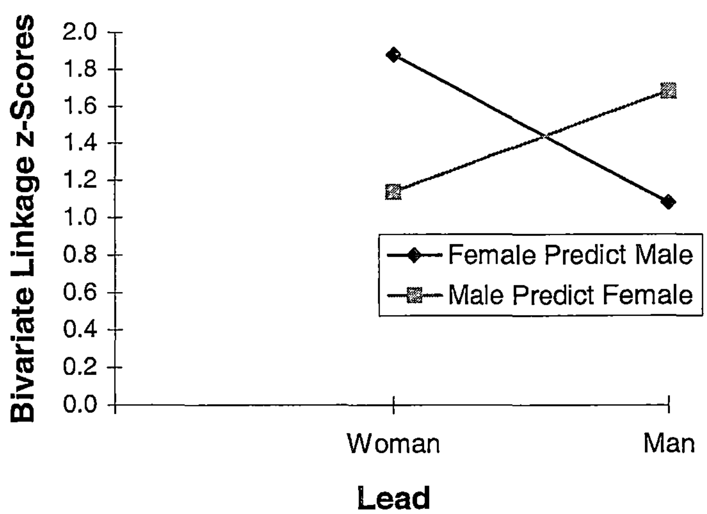

Figure 2. Overall level of physiological linkage (male response pattern predicting female response pattern and female response pattern predicting male response pattern) when the man and the woman is leading the conversation.

Analysis within each topic, using Greenhouse-Geisser correction, indicated that the Lead x Predict interaction was the only significant result for all three topics. During the neutral segment the result for Lead x Predict was $F(1, 19) = 21.67$, $p < .001$; for the happy segment Lead x Predict was $F(1, 19) = 18.50, p < .001$; and for conflict $F(1, 19) = 7.89, p = .01$. Post hoc analysis of the Lead x Predict interaction (using two-tailed *t* tests) for each topic revealed that a fully crossed interaction occurred during the neutral segment only (all *p*s < .05), while two of the four post hoc comparisons were significant for the happy and conflict discussion segments. Thus, there was consistency in results for physiological linkage across topics, where the physiology of the person who was listening was following the physiology of the person leading the discussion.

In summary, the results of the separate analyses for the percentage and strength of physiological linkage were quite consistent. The overall result for each analysis was that the physiology of the person leading the conversation predicted the physiology of the person listening.

Physiological Linkage and Perspective-Taking Measures

To assess the second hypothesis, that physiological linkage would be predictive of perspective-taking, the following analyses were undertaken. First, the perspective-taking scales were analysed for gender differences to evaluate if it was appropriate to combine scores for men and women and derive a couple perspective-taking score. This was followed by correlational analysis to examine if a simple index of physiological linkage for each couple predicted any of the perspective-taking measures. For the final analysis, hierarchical multiple regression was used to examine how well combinations of physiological linkage variables (for male and female lead, across all three physiological variables) accounted for the variance in perspective-taking scores.

Perspective-taking measures and gender differences. ANOVAs on the SDPT and ODPT scales indicated that there were no significant gender differences in the overall rating of self perspective-taking or other perspective-taking. Similarly, there were no significant gender differences within the Strategies or Cognizance subscales of either the SDPT or ODPT. Thus, men and women rated themselves, and each other, as having the same ability in perspective-taking. Given these results, male and female perspective-taking scores were combined for later analysis with bivariate scores.

Correlational analysis of couple perspective-taking with an index of couple physiological linkage. To examine the relationships between the couple perspective-taking measures and physiological linkage, a simple index of physiological linkage was required for each discussion segment depending on who was leading the discussion in the segment. To achieve this an average of the six bivariate scores was computed for each couple during each segment. This resulted in two indices of physiological linkage for each couple during each discussion segment, where one index represented the average level of physiological linkage when the man led the discussion, and the other index represented the average level of physiological linkage when the woman led the discussion. Pearson product-moment correlations of the SDPT and ODPT scales and subscales, with the indices of physiological linkage, resulted in no significant correlations (all $ps > .05$).

Hierarchical multiple regression of physiological linkage with couple perspective-taking. Hierarchical multiple regression was used to assess how much of the variance in perspective-taking measures could be accounted for by physiological linkage. For this analysis the original six bivariate linkage variables for *male lead* and *female lead* were used as potential predictors of perspective-taking. As the number of cases was 20 and Tabachnick and Fidell (1989) recommend a minimum ratio of 5:1 between predictor variables and cases, a maximum of four variables were allowed to enter into the regression analysis. Selection of variables was determined in the following way. First, simple correlations between each of the six bivariate physiological linkage scores (for male lead *and* female lead) and the combined (male plus female) SDPT and ODPT overall and subscale perspective measures were examined. The four highest correlations of male lead and female lead for each discussion segment were noted. Then, stepwise regression (with $p = .05$ entry, $p = .01$ exit) was used to evaluate which combination of physiological linkage variables best predicted each of the perspective-taking measures during each interaction segment for male lead and female lead.

These preliminary analyses enabled selection of up to four variables for use in the hierarchical regression analysis. The primary purpose of this analysis was to assess the amount of variance in perspective-taking that was accounted for by physiological linkage. Therefore, only summary statistics for the final predictions are provided in Tables 2, 3, and 4. Intermediate steps in the analysis are not reported.

In Table 2 the overall results for the SDPT and ODPT measures are illustrated. A clear outcome was that for the conflict interaction, when the man or the woman led the conversation, physiological linkage was significantly correlated with both perspective-taking measures, and accounted for 20% to 52% of the variance in perspective-taking. A breakdown of these results across the cognizance and strategies subscales of the SDPT and ODPT are shown in Tables 3 and 4. Examination of Table 3 indicates that the overall result for the SDPT measure arose when the cognizance and strategies subscales were combined. However, from Table 4, both the ODPT cognizance and strategies subscales were significantly predicted by physiological linkage during the conflict interaction segment when the man or the woman led the discussion. Thus, the relationships between physiological linkage and the ODPT measures were more robust than those between the SDPT measures and physiological linkage.

Table 2

Summary of Hierarchical Regression Analysis for Physiological Linkage Variables Predicting Overall Self Dyadic Perspective-Taking (SDPT) and Other Dyadic Perspective-Taking (ODPT)

	Man is principal speaker			Woman is principal speaker		
Perspective measure	Neutral	Happy	Conflict	Neutral	Happy	Conflict
SDPT						
R^2	0.15	0.09	0.2	0.17	0.17	0.31
F-value	3.27	1.83	4.63	3.64	3.79	3.78
p-value	0.09	0.19	0.05*	0.07	0.07	0.04*
ODPT						
R^2	0.16	0.27	0.33	0.14	0.18	0.52
F-value	3.44	3.20	4.17	1.42	3.83	5.67
p-value	0.08	0.07	0.03*	0.27	0.07	0.008**

*$p < .05$. **$p < .01$.

Table 3

Summary of Hierarchical Regression Analysis for Physiological Linkage Variables Predicting Self Dyadic Perspective-Taking (SDPT) Cognizance and Strategies Subscales

	Man is principal speaker			Woman is principal speaker		
Perspective measure	Neutral	Happy	Conflict	Neutral	Happy	Conflict
SDPT Cognizance						
R^2	0.09	0.19	0.26	0.32	0.16	0.16
F-value	1.81	4.15	1.90	1.76	3.37	3.37
p-value	0.20	0.06	0.17	0.19	0.08	0.08
SDPT Strategies						
R^2	0.21	0.11	0.17	0.08	0.10	0.40
F-value	4.76	1.03	3.70	1.64	2.01	5.57
p-value	0.04*	0.38	0.07	0.22	0.17	0.01*

*$p < .05$.

Table 4

Summary of Hierarchical Regression Analysis for Physiological Linkage Variables Predicting Other Dyadic Perspective-Taking (ODPT) Cognizance and Strategies Subscales

	Man is principal speaker			Woman is principal speaker		
Perspective measure	Neutral	Happy	Conflict	Neutral	Happy	Conflict
ODPT Cognizance						
R^2	0.19	0.26	0.45	0.20	0.23	0.47
F-value	2.05	3.30	4.29	1.33	5.51	7.60
p-value	0.16	0.08	0.02*	0.30	0.03*	0.004**
ODPT Strategies						
R^2	0.30	0.27	0.15	0.28	0.12	0.55
F-value	1.61	3.01	4.33	2.05	2.42	6.43
p-value	0.22	0.07	0.05*	0.15	0.14	0.005**

$*p < .05$. $**p < .01$.

Physiological Linkage and Marital Satisfaction

To assess the third hypothesis of the predictive relationships between marital satisfaction measures and physiological linkage simple correlational analysis and hierarchical multiple regression analysis were used. For the hierarchical multiple regression analysis the same variable selection process that was outlined for the regression analysis of physiological linkage with perspective-taking was used. Pearson product-moment correlations between the combined scores for men and women on the KMSS and QMI, with the simple index of physiological linkage for each couple during each interaction segment, resulted in no significant correlations for any of the three interaction segments when the man or the woman led the discussion (all *ps* > .05).

The results for the hierarchical multiple regression analysis are summarised in Table 5. Results for the KMSS indicate that physiological linkage significantly predicted marital satisfaction for five of the six interaction segments and accounted for up to 51% of the variance in marital satisfaction. The results for the QMI were similar, where significant results emerged for four of the six interaction segments and physiological linkage accounted for up to 44% of marital satisfaction.

Table 5

Summary of Hierarchical Regression Analysis for Physiological Linkage Variables Predicting the Kansas Marital Satisfaction Scale (KMSS) and the Quality of Marriage Index (QMI)

Marital satisfaction	Man is principal speaker			Woman is principal speaker		
measure	Neutral	Happy	Conflict	Neutral	Happy	Conflict
KMSS						
R^2	0.29	0.16	0.51	0.23	0.33	0.42
F-value	3.47	1.64	5.64	5.48	2.67	3.90
p-value	0.05*	0.20	0.008**	0.03*	0.08*	0.03*
QMI						
R^2	0.32	0.13	0.44	0.23	0.35	0.35
F-value	3.70	2.59	3.88	2.36	4.23	4.25
p-value	0.05*	0.13	0.03*	0.13	0.03*	0.03*

*$p < .05$. **$p < .01$.

Perspective-Taking and Marital Satisfaction

To assess the fourth hypothesis, Pearson product-moment correlations were computed between couple perspective-taking measures and measures of marital satisfaction. The results are presented in Table 6.

Table 6

Correlations of Self Dyadic Perspective-Taking (SDPT), and Other Dyadic Perspective-Taking (ODPT) with the Kansas Marital Satisfaction Scale (KMSS) and the Quality of Marriage Index (QMI)

Marital satisfaction measure	Perspective-taking measures					
	SDPT			ODPT		
	Overall	Cognizance	Strategies	Overall	Cognizance	Strategies
KMSS						
r	0.55	0.52	0.41	0.68	0.68	0.65
p value	0.013*	0.018*	0.073	0.001**	0.001**	0.002**
QMI						
r	0.40	0.39	0.32	0.64	0.61	0.65
p value	0.086	0.097	0.184	0.003**	0.006**	0.003**

*$p < .05$. **$p < .01$.

The ODPT overall scale and subscales were highly correlated (all *r*s > .6, *p*s < .01) with both marital satisfaction questionnaires in the predicted direction, where higher levels of perspective-taking were associated with higher levels of marital satisfaction. For the SDPT perspective measure significant positive correlations occurred for the overall scale and the cognizance subscale with the KMSS. No significant relationships emerged between QMI and any of the SDPT measures.

Physiological Arousal Levels During Baseline and Discussion Segments

As discussed in chapter 5, comparison of baseline levels of arousal with levels of arousal during discussions was considered appropriate to determine whether the experimental manipulation produced reliable changes in arousal. In addition, examination of baseline levels of arousal would indicate if couples had the same baseline levels prior to each discussion segment. This combined information was expected to assist interpretation of the results for physiological linkage.

Baseline analysis. All couples commenced with neutral discussion segments after a 4 min baseline. To examine how well couples returned to baseline levels between the happy and conflict discussion segments, raw scores for HR, FPA, and PTT were compiled for men and women for each of the three 4 min baselines. Preliminary examination of data revealed three outliers (greater than three *SD*s away from the mean) which were replaced with the mean for the respective physiological variables. As raw scores were used, each physiological variable was analysed separately. Repeated measures ANOVAs of Topic x Gender (3 x 2), with Greenhouse-Geisser correction, resulted in a significant main effect of topic for HR,

$F(1.86, 35.25) = 14.96$, $p < .001$, and a significant main effect of topic for PTT, $F(1.46, 27.81) = 6.66$, $p < .01$. No significant main effects or interactions emerged for FPA. Post hoc comparisons (using Tukey's LSD) indicated that HR for men and women during the neutral baseline was significantly higher than the happy baseline ($p < .05$ for men, $p < .01$ for women). For women, HR during the neutral baseline was significantly higher than the conflict baseline ($p < .001$), and for men approached significance ($p = .06$). For women PTT was also significantly lower during the neutral baseline than the other two baselines (*p*s < .05).

Results for baseline analysis indicated that men and women generally exhibited higher levels of arousal (higher HRs for men, higher HRs and lower PTTs for women) during the neutral baseline than the other two baselines.

Arousal levels for baselines and subsequent discussion segments. To evaluate whether arousal levels varied between baselines and the following discussion segments, raw data of HR, FPA, and PTT for men and women for each of the three discussion segments were compiled for comparison with raw baseline data. Male physiological data was combined across man lead and woman lead for each discussion segment. Female data was combined in the same way. Thus, three measures of arousal (HR, FPA, and PTT) for the man and woman, for each of the discussion segments were derived. Separate 3 x 2 (Topic x Arousal) repeated measures ANOVAs, with Greenhouse-Geisser correction, were computed for men and women for each physiological variable. Post hoc analyses were computed with Tukey's LSD tests.

For male HR a significant main effect was found for topic, $F(1.92, 36.41) = 3.70$, $p = .03$, and arousal, $F(1, 19) = 4.87$, $p = .04$. For female HR there was also a significant main effect for topic, $F(1.33, 25.17) = 15.20, p < .001$, and arousal, $F(1, 19) = 22.32, p < .001$. These effects for men and women are illustrated in Figures 3 and 4, respectively. Another result for women was a significant main effect of topic for PTT, $F(1.95, 37.07) = 3.97, p = .03$. No significant main effects or interactions emerged for FPA for either men or women.

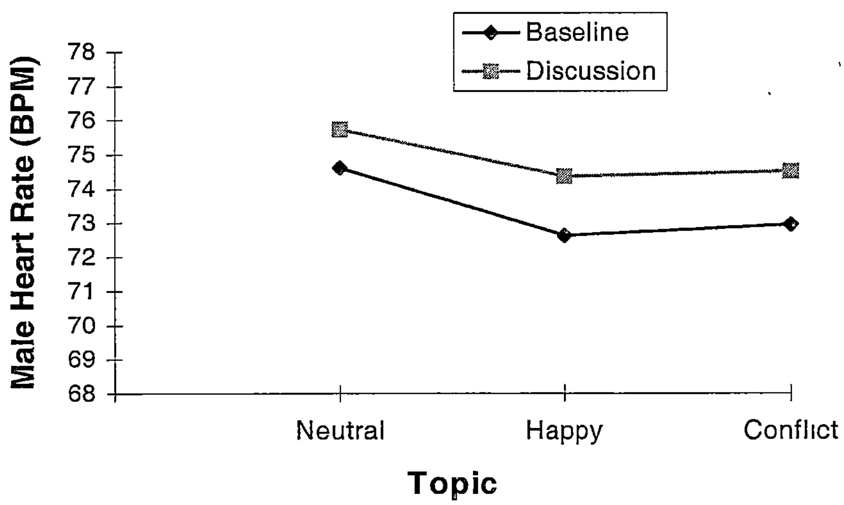

Figure 3. Male heart rate, in beats per minute (BPM), during each baseline and subsequent discussion segment for three topics.

Post hoc analysis of the main effect of topic for male HR indicated that, higher levels of arousal occurred during the discussion segment than the preceding baseline for conflict ($p < .05$), approached significance for happy ($p = .06$), and was non significant for neutral ($p > .05$). Post hoc analysis of the main effect of arousal for male HR indicated that arousal levels were higher during the neutral segment than the happy segment ($p < .03$), and approached significance for the comparison between the neutral segment and the conflict segment ($p = .06$). Post hoc analysis of the main effect of topic for female HR indicated that higher levels of arousal occurred during all discussion segments than preceding baselines (all ps $< .01$). Post hoc analysis of the main effect of segment for female HR indicated that arousal levels were higher during the neutral segment than the other two segments ($ps < .01$). The main effect of topic for female PTT indicated a lower level of PTT during the neutral segment that the other two segments ($ps < .05$).

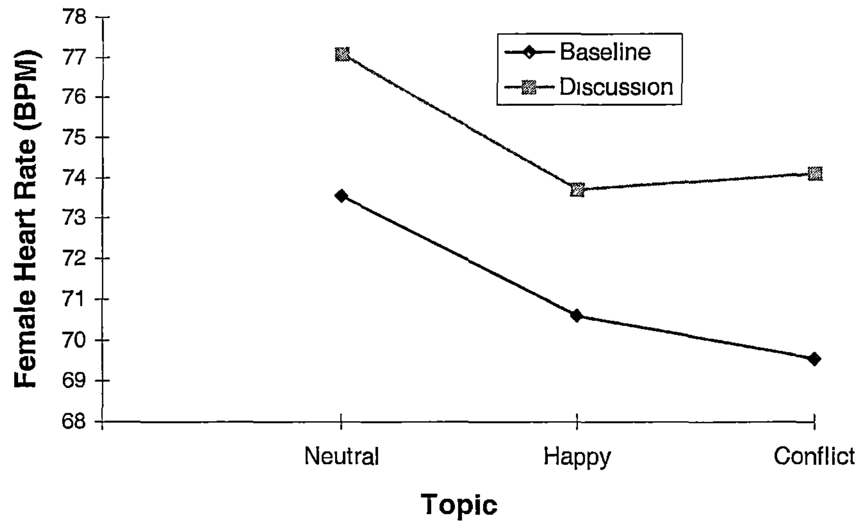

Figure 4. Female heart rate, in beats per minute (BPM), during each baseline and subsequent discussion segment for three topics.

This analysis indicated that arousal levels were higher (as indicated by higher HRs for men and women) when couples were engaged in interactions than when they were waiting for the interactions to begin. The effects for levels of arousal across topics indicated that both men and women exhibited higher levels of arousal during the neutral segment than the other two segments (higher HRs for men, higher HRs and lower PTTs for women). This pattern of arousal across topics reflected the earlier results found for the analysis of baselines.

Chapter 7

Discussion

Chapter 7

Discussion

In this chapter the support for the proposed model of empathy is reviewed and the issue of whether physiological linkage signifies the feeling component of empathy. Subsequently, the mechanisms that mediate physiological linkage are briefly discussed and directions for future research.

However, it should be noted that the methodology of this research is itself important. It involved the development of a strategy for the collection and initial synthesis of sequential physiological data using an eight channel MacLab system. This included writing a set of macro programs to provide sequential averages of raw data for heart rate (HR), skin conductance level (SCL), and finger pulse amplitude (FPA). It also included defining a strategy for the measurement of pulse transmission time to finger (PTT) and writing another series of macro programs to detect the pulse wave maximums of HR and FPA for later synthesis into sequential averages.

A second methodological development involved the definition of a standardised approach to the analysis of bivariate time-series data. Central to this was the use of sequential residualised change scores to control for initial-value dependency in data. A review of the law of initial value (LIV) literature highlighted the importance of controlling for this potential confound in the analysis of physiological data. The use of residualised change scores was critical as a scan of the raw data for the current research indicated that differences in baseline levels, between men and women, of 25% for HR and over 60% in FPA occurred for some couples.

These differences, if not controlled for, were likely to lead to spurious results and incorrect interpretation of outcomes in data.

As a first step in developing a standardised approach to the analysis of bivariate data a computer program was written that produced sequential residualised change scores for all physiological data. Other steps included (a) checks for stationarity in bivariate data and control for stationarity as required, (b) the use of spectral density and lag cross correlational analysis plots of physiological data to assist in the selection of appropriate starting values for the analysis of physiological linkage, and (c) the use of more than one starting value for the analysis of physiological linkage to evaluate the robustness of the bivariate time-series analysis.

Only when this detailed treatment of the data was completed could the hypotheses for the current research be appropriately tested.

Hypothesis 1: The Physiology of the Listener Would Follow the Physiology of the Speaker During all Discussion Segments

The hypothesis that the physiology of the listener would follow the physiology of the principal speaker during all three discussion segments was supported. Significant levels of physiological linkage occurred for 38% of the physiological variables during the neutral discussion, 42% during the happy discussion, and 41% during the conflict discussion. This result was higher than, but consistent with, the earlier study of Levenson and Ruef (1992) who found that independent observers were physiologically linked to a target spouse for 28% and 33% of the physiological variables when viewing and rating two videotapes. The higher percentages of physiological linkage in the current study are most likely due to couples having a better empathic understanding of their partner's feelings than a stranger viewing a videotape of couple interactions. This better empathic understanding between couples would typically be due to knowledge of partner's beliefs, value systems, the rules and assumptions they apply in particular situations (Oliver, 1975), and detailed interpersonal knowledge and shared experience (Smither, 1977).

There were no gender differences for physiological linkage in the earlier Levenson and Ruef (1992) study. Similarly, for the current study, the percentage of significant physiological linkage was equivalent across gender and topics. That is, a similar percentage of physiological variables resulted in physiological linkage, where the physiology of the listener followed the physiology of the person who led the conversation, independent of whether the topic was neutral, happy, or about a conflict with a third party. These results extend the earlier findings of Levenson and Ruef (1992) to the expression of neutral and positive affect. The absence of outcomes for physiological linkage with positive affect in their study was probably due to the paucity of positive affect in the videotapes. Levenson and Ruef acknowledged this possibility in a footnote.

The findings of the current study for significant levels of physiological linkage during the expression of different types of affect are consistent with: (a) the earlier DiMascio Boyd and Greenblatt (1957) study where a link was found between client and therapist heart rate during the expression of three different types of emotion by the client (i.e., tension, tension release, and antagonism); (b) the finding of Kaplan et al. (1964; Study 1) of physiological covariation between dyads who liked or disliked each other when they interacted socially; and (c) the finding of Wagner and Calam (1988) that physiological linkage occurred during parent-child interactions when data was combined across three types of discussion (events of the day, tidying the bedroom, and spending the money).

The expectation that physiological linkage would not be confined to the expression of negative affect was supported by the current study. Physiological linkage occurred when couples discussed neutral, happy, and conflictual topics. These results suggest that physiological linkage is a robust phenomenon that occurs when people listen empathically to each other.

While the percentage results of the current study described how often physiological linkage occurred, and are suggestive that the experimental manipulation of directing each spouse to listen empathically to their partner produced them, causality cannot be inferred directly. Despite this limitation the subsequent repeated measures ANOVAs of the percentage scores of significant physiological linkage *and* all bivariate scores for the strength of linkage yielded equivalent results. The overall outcome for each analysis was a fully crossed interaction between lead and predict where the physiology of the person leading the conversation predicted the physiology of the designated listener significantly better than the physiology of the listener predicted the physiology of the speaker. These relationships generally held for both analyses across all three topic segments. These results indicate that the predominant direction of influence during each discussion segment was from the person leading the conversation to the designated listener. The most likely basis for this outcome was the experimental manipulation of asking each partner in turn to listen empathically to his or her spouse.

That couples were attending empathically to each other and that this produced an outcome at a physiological level was further corroborated by the presence of bidirectional physiological linkage. While the strongest effect was that the physiology of the designated speaker predicted the listener's physiology during interaction segments (for 40% of the physiological variables), simultaneously and at a lower level, the designated speaker's physiology was frequently following the physiology of the listener (for 12.5% of the physiological variables). These results indicate that at a physiological level a two-way communication exchange was occurring that influenced the physiological linkage between couples. These outcomes support Lacey's (1959) position on the interactional nature of communication exchange and the effects this may have on the data obtained.

Finally, the increase in levels of arousal between baselines and subsequent discussion segments (as indicated by higher HRs for men and women) indicated that the experimental manipulation of asking one spouse to tell a story and the other to listen empathically, produced effects at a physiological level. This outcome provides further support that the results for physiological linkage were similarly dependent on the experimental manipulation of empathic listening.

Other outcomes for arousal levels require some comment. For example, couples were more aroused physiologically during the neutral baseline and discussion segment than in the other two segments. The higher arousal during the first neutral discussion was most likely to have been due to anticipatory anxiety as couples consistently appeared to become more relaxed after the neutral discussion. This was corroborated by comments from couples at the end of the laboratory session. Several couples commented that participation in the study was less difficult and more enjoyable than they thought it would be. A few couples even commented that participation enabled them to sit down and listen to each other for the first time in weeks.

In summary, the consistency of outcomes across the different types of analysis for physiological linkage suggest that when one person listens empathically to their partner, the couple become linked physiologically, where the dynamic changes in the physiology of the person leading the conversation are followed by their partner.

Hypothesis 2: Physiological Linkage Would be Predictive of Perspective-Taking

The results of multiple hierarchical regression analysis provided support for this hypothesis. For the overall Self Dyadic Perspective-Taking (SDPT) and Other Dyadic Perspective-Taking (ODPT) scales, physiological linkage significantly accounted for 20% to 52% of the variance in perspective-taking during conflict when the man or the woman led the discussion. No relationships emerged for the overall SDPT or ODPT scales for the neutral or happy discussions. A breakdown of the hierarchical regression across the strategies and cognizance subscales revealed an additional result for the neutral interaction, when the man led the conversation, and for the happy interaction when the woman led the discussion.

These overall results suggest that significant outcomes could emerge for all three topics with a larger sample. However, some qualifications are warranted. For example, feedback from couples indicated that some of them found the neutral discussions to be quite interesting. They explained that listening attentively enabled them to appreciate what they previously considered to be boring topics - such as dungeons and dragons for women, and knitting for men. Thus, this is a potential confound to be controlled for in future studies. When this phenomenon became evident during the current study the author began administering simple visual analogue scales after each discussion. Couples were asked to rate, on a scale of 1 to 10, how boring, happy, or conflictual, they considered the story to be. Although insufficient data was available to separately analyse across this dimension for the current study, the use of visual analogue scales is recommended for future studies to evaluate affective content.

The strongest and most consistent results emerged for the ODPT scales. This suggests that partner ratings of each other (ODPT) could be more strongly related to physiological linkage than self ratings of perspective-taking (SDPT). Moser's (1984) finding, that peer ratings of role-taking abilities were more reliable than self ratings of role-taking abilities, offers some support for this position. However, caution is warranted for two reasons. Firstly, it has yet to be determined if the ODPT is a more valid measure of perspective-taking than the SDPT. Further studies on the SDPT and ODPT scales are required to specifically address this issue. Secondly, in the current study four results for the SDPT subscales approached significance. Thus, the stronger findings for the ODPT could be sample specific. A study of physiological linkage using a larger sample would assist in resolving if the ODPT scale is more reliably associated with physiological linkage than the SDPT. That is, a larger sample size will provide increased statistical power for the detection of smaller effects.

Differences in outcomes for this study and the Levenson and Ruef (1992) study require some comment. In the current study no relationships emerged for simple correlations between an overall index of physiological linkage and the SDPT or ODPT scales. In contrast, Levenson and Ruef found a significant correlation between their simple index of physiological linkage and rating of negative affect. The absence of a similar result in the current study was somewhat surprising as there was a perceived similarity between the perspective-taking task in the current study and the affective rating task in the Levenson and Ruef study. Both tasks were considered to be cognitively mediated and it was expected that the better one was at the task the higher the level of physiological linkage. Implicit in this reasoning, for the current study, was that perspective-taking would assist physiological linkage to occur. The results for the first hypothesis of the current study suggest that empathic listening may provide a direct pathway for physiological linkage to occur during couple interactions. It is likely that the absence of high levels of negative affect during the current study, and the probable lower levels of tension or involvement, prevented this effect from emerging for simple correlational analysis. A change in methodology, where couples are asked to present their side of a particularly contentious issue in their relationship, should produce the higher levels of involvement that may be required for significant outcomes to occur at this level of analysis. This suggestion is consistent with the earlier results of Levenson and Gottman (1983) where significant correlations were only found for interactions with high levels of negative emotional intensity.

In summary, considerable support was provided for the hypothesis that physiological linkage would be predictive of perspective-taking ability. The majority of support emerged from multiple hierarchical regression analysis where significant outcomes were found for all discussion topics. The most consistent outcomes were found for the conflict discussion and for the ODPT scales.

Hypothesis 3: Physiological Linkage Would be Predictive of Marital Satisfaction

Substantial support for this hypothesis was provided from multiple hierarchical regression analysis between physiological linkage variables and marital satisfaction measures. Physiological linkage significantly accounted for 23% to 51% of the variance in the KMSS and 32% to 44% of the variance in the QMI. For the KMSS five of the six analyses were significant. This indicates consistency in prediction of variance in marital satisfaction across each topic of discussion, with the highest predictions for the conflict discussions. For the QMI four of the six regression analyses were significant with results for all topics. Again the highest predictions occurred for the conflict discussion. The similarity in results for the KMSS and QMI is corroborated by the high correlation between these measures of marital satisfaction; $r = .89, p < .001$. This level of association is consistent with the finding of Schumm et al. (1986) that the KMSS was correlated with the QMI at $r = .91, p < .001$. The levels of prediction found between physiological linkage and the outcome variable of marital satisfaction are quite impressive because questionnaire measures typically account for less than 10% of the variance in marital satisfaction, and observational methods account for about 25% (e.g., Wagner & Calam, 1988).

Comparison of the results for multiple hierarchical regression and marital satisfaction for the current study and that of Levenson and Gottman (1983) provides some insight into what physiological linkage represents in each of these studies. Levenson and Gottman (1983) found that physiological linkage accounted for 60% of the variance in marital satisfaction during conflict resolution for distressed couples. On the basis of their results Levenson and Gottman (1983) considered that physiological linkage reflects "...the ebb and flow of negative affect…" (p. 596). This interpretation is consistent with the conflictual context and the high levels of negative affect reciprocity that occurred. However, in the current study only couples in non-distressed relationships participated. Also, there was consistency in prediction of variance in marital satisfaction across three types of affect. These results suggest that the physiological linkage that occurred in the current study represented a more global aspect of the relationship than simply the exchange of negative affect. The finding that the physiology of the listener generally followed the physiology of the speaker during all discussion segments (hypothesis 1) supports this contention. The high levels of prediction found between physiological linkage and perspective-taking (hypothesis 2) adds further support that empathic listening produced the physiological linkage. Thus, the most likely explanation for the results between physiological linkage and marital satisfaction in the current study is as follows. Physiological linkage represents, to some extent, the empathic listening skills of the couple. These skills are consistent across different types of affect. The outcome is that empathic listening is reliably predictive of levels of marital satisfaction. This interpretation is in accordance with the proposed three stage model of empathy (see chapter 2) in which empathy was expected to lead to positive outcomes.

While multiple hierarchical regression provided support for hypothesis 3, no significant relationships emerged between the simple index of physiological linkage and marital satisfaction. As discussed earlier, the absence of higher levels of tension during couple discussions was probably responsible for the absence of this effect at this lower level of analysis.

In summary, the results of multiple hierarchical regression provided substantial support that physiological linkage was predictive of marital satisfaction. These results, in conjunction with the results for physiological linkage and perspective-taking, suggest that physiological linkage found in the current research reflects the level of empathic listening skills in couple relationships.

Hypothesis 4: Measures of Perspective-Taking Would be Positively Correlated with Measures of Marital Satisfaction

This hypothesis was supported. The strongest relationships were found between the ODPT measures and the marital satisfaction questionnaires. Self rating of perspective-taking (SDPT) was less reliably associated with marital satisfaction. These results are consistent with the Davis and Oathout (1987) finding that a positive evaluation of partner perspective was associated with higher levels of satisfaction with the relationship. These results suggest that partner perception of perspective-taking abilities could be more valid than self rating of perspective-taking. Support, at a physiological level, was provided for this proposition from the results reported for hypothesis 2 where it was found that stronger relationships emerged between physiological linkage and the ODPT scales than between physiological linkage and the SDPT scales. These combined results suggest that how partners view each other is a more important determinant of marital satisfaction than how each partner views themself. Long and Andrew's (1990) finding that husbands' and wives' perceptions of their partner's perspective-taking ability were predictive of marital adjustment supports this suggestion. Also consistent with this view was Long's (1993) finding that "Males and females in high-adjustment relationships had more positive perceptions of their partner's dyadic perspective-taking than individuals in low-adjustment relationships" (p. 254).

In summary, the proposed relationships between perspective-taking and marital satisfaction measures were supported. Of interest were the more consistent relationships between the ODPT scales and marital satisfaction. This may indicate that partner perception of perspective-taking ability is a more reliable predictor of marital satisfaction than self rating of perspective-taking. While the results from other studies are consistent with this proposition, further research is required to evaluate the reliability of these findings.

Support for the Proposed Three Stage Model of Empathy

Substantial support was provided for the proposed three stage model of empathy. In Stage 1 of the model it was proposed that knowing and feeling what another person was feeling would assist in developing an accurate understanding of another's affective state. While a direct measure of knowledge of another's affect was omitted from the current study (such as an affective rating dial), evidence was found that couples understood the affective state of each other. For example, the presence of physiological linkage during all topics of discussion indicated that at a physiological level couples were following each other. Additionally, couples rated each other as having equivalently high levels of perspective-taking ability. That is, the non-distressed couples who participated in this study, considered themselves (SDPT) and each other (ODPT) to have high levels of global awareness of how their partner feels (cognizance subscales). They also actively use strategies such as role-taking to gain a better understanding of how their partner feels (strategies subscales). Evidence of the proposed interaction between the cognitive understanding of what another person is feeling and feeling what another person is feeling, was provided by the high level of association found between perspective-taking and physiological linkage.

Stage 2 of the model was manipulated experimentally by asking each couple in turn to listen empathically to their partner. As the effectiveness of this manipulation was not measured separately, evidence for the success of this manipulation was indirect and provided by examining the relationships between

Stage 1 and Stage 3 of the model. Both the feeling component (as per physiological linkage) and the knowing component (via perspective-taking) of empathy were found to be reliably associated with the outcome measure of marital satisfaction. Thus, when couples listened empathically to each other, physiological linkage was highly predictive of marital satisfaction and perspective-taking. These results provide substantial support that knowing and feeling what another is feeling will enable an empathic response to occur (i.e., empathic listening) and that this will in turn lead to positive outcomes such as increased marital satisfaction. While the results of the current study were consistent with this assertion, causation could not be demonstrated, and changes in methodology are required to directly test this hypothesis.

The results for the current study demonstrated the utility of the three stage model of empathy for the conceptualisation and analysis of empathy in dyadic interactions.

Does Physiological Linkage Signify the Feeling Component of Empathy?

The results from the current study support the proposition that physiological linkage represents the feeling component of empathy when non-distressed couples engage in empathic listening. The majority of evidence for this assertion emerges from the experimental manipulation of placing each spouse in an empathic listening role. The presence of significant levels of physiological linkage throughout all discussion segments indicated that, when spouses listened empathically to their partner, they became linked physiologically independent of the type of topic being discussed. The predominant direction of physiological linkage was that the person listening empathically was following their partner. That is, the dynamic changes in the physiology of the person leading the conversation were followed by equivalent dynamic changes in the physiology of the person who was listening empathically. This suggests that the person listening empathically is 'feeling along with' their spouse at a physiological level. This following of the moment by moment changes in feeling at a physiological level, while understanding what another person is feeling, *is* the feeling component of empathy. That each spouse understood their partner was demonstrated by their high levels of perspective-taking abilities and the high levels of prediction found between perspective-taking and the corresponding levels of physiological linkage. Consequently, strong support was provided in the current study that physiological linkage represents the feeling component of empathy. This conclusion is consistent with the Robinson et al.'s (1982) finding of significant correlations between client ratings of counsellor empathy and the matching of phasic physiological activity.

However, the presence of physiological linkage does not always signify the feeling component of empathy. For example, in the Levenson and Gottman (1983) study the physiological linkage that occurred was interpreted as representing the high levels of negative affect and the reciprocity of negative affect. Similarly, the early studies of dyadic interactions corroborate that shared physiology occurs in situations of high levels of anxiety (Malmo, Boag & Smith, 1957), perceived threat (Dittes, 1957), dislike (Kaplan et al., 1964), or the exchange of emotionally significant information (Roessler et al., 1975). Consequently, as discussed by Gottman and Ringland (1981), it is important to assess the context in which physiological linkage occurs prior to interpreting what the presence of physiological linkage signifies. The implication is that one may not conclude that empathy has occurred by the presence of physiological linkage alone.

Mechanisms that Mediate Physiological Linkage

The results from the present research and other studies on dyadic interactions are suggestive that different mechanisms or processes may mediate physiological linkage in different contexts or during the expression of different types of affect. Plausible processes include: (a) empathic listening, (b) emotional contagion that may be cognitively mediated; and (c) emotional contagion mediated via a relatively automatic threat response. For the current study the results suggest that empathic listening was the primary process that mediated physiological linkage as equivalent levels of physiological linkage occurred during all discussion segments. In contrast, the results of Levenson and Gottman (1983) suggest that physiological linkage was mediated via a threat response, the presence of high levels of negative affect, affective dominance, or a combination of these factors. For the later Levenson and Ruef (1992) study the raters were placed in an empathic listening role and physiological linkage only occurred for conflict interactions. It was unclear whether the cognitive task of rating negative affect produced physiological linkage, or whether physiological linkage occurred due to emotional contagion in the presence of high levels of negative affect.

The consistency of results for negative affect in the earlier studies of physiological linkage (Levenson & Gottman, 1983; Levenson & Ruef, 1992) suggest that there is something more salient about the physiological linkage that occurs during the expression of negative affect. For the present study the highest levels of prediction for physiological linkage with marital satisfaction *and* perspective-taking occurred for the discussions of conflict. This result supports the proposition that stronger effects may occur for physiological linkage during the expression of negative affect.

At this time it is unclear which mechanisms may mediate physiological linkage in a given instance and whether physiological linkage levels are higher during the expression of negative affect or the perception of threat. Further studies are required to elucidate these issues.

Directions for Future Research

While the results for the current research suggest that physiological linkage is a robust phenomenon that reliably occurs when one person listens empathically to another, replication studies are required to corroborate this finding. As might be inferred from the beginning of this chapter, a standardised approach to the treatment of bivariate data would be an important step forward in such studies. Further, some refinements in the methodology used for the current research are suggested. For example, a simple check on the empathy manipulation would improve the interpretation of results. This could be achieved by asking the spouse relating the story to rate the degree of empathy shown by their partner. Further, by asking each spouse to rate how boring, happy, or conflictual, they found each discussion to be will assist in evaluating the affective content in each experimental condition. Additionally, for the conflict interaction, asking each spouse in turn to present their side of a contentious issue in the relationship is suggested. This change is likely to increase the intensity of the interaction and introduce interpersonal conflict, which was relatively absent in the current research. This change in methodology may provide additional insight into whether the presence of negative affect is more salient and produces higher levels of physiological linkage than the expression of positive or neutral affect.

Another suggested area for future research is to examine whether physiological linkage is reliably associated with the activation of specific brain structures for the expression of different types of affect. For example, MacLean (1990) proposed the concept of the 'triune brain' where, from an evolutionary perspective, the brain was considered to constitute a hierarchy of three relatively distinct brain structures: 1. The 'reptilian brain' which is the most primitive and responsible for basic survival responses including the 'fight or flight' response, and the regulation of basic bodily functions such as breathing, sleeping, and sexual behaviour. 2. The 'mammalian brain' which provides an emotional or feeling overlay to complement and extend the basic survival functions of the reptilian brain. This new level of brain structure enabled the sensations of liking and disliking. 3. The most recent development, from an evolutionary perspective, is the neocortex that was viewed as providing the capacity for abstract thought and the ability to integrate information from the mammalian and reptilian brains. The neocortex enabled one to be aware of instinctual drives, know one's preferences and then make a decision by evaluating available options and likely outcomes.

Using Positron Emission Tomography (PET; which provides information on the relative blood flow throughout the brain) could enable one to evaluate which structures of the brain are primarily engaged during empathic listening or the expression of different types of affect (e.g., Groves & Rebec, 1992; Walsh, 1994). Using MacLean's topography one would expect: (a) the reptilian brain to be primarily activated in highly conflictual situations that are perceived as threatening; (b) the mammalian brain to be primarily engaged for situations involving the expression of emotionally salient information; and (c) the neocortex to be primarily involved in the processing of information during empathic listening in a non threatening context.

Summary and Conclusion

The current research examined physiological linkage in dyadic couple interactions and whether physiological linkage signified the feeling component of empathy. The presence of physiological linkage indicates that the dynamic changes in the physiological response of one person are followed by equivalent dynamic changes in the physiological response of another.

The results for the current research indicate that physiological linkage is a robust phenomenon that occurs when one spouse listens empathically to their partner. Physiological linkage occurred reliably between spouses during the expression of neutral, positive, and negative affect. The percentage of variables for which significant physiological linkage occurred was 38% during the neutral discussions, 42% during the happy discussions, and 41% during the conflict discussions. These results were consistent with the earlier finding of Levenson and Ruef (1992) that strangers were physiologically linked to a target spouse for 28% and 33% of the physiological variables when rating two videotapes of couple interactions.

The direction of physiological linkage was that the physiology of the person leading the conversation was consistently followed by the physiology of the designated listener. This outcome generally held across all topics of discussion and was consistent for the analysis of the percentage and the strength of physiological linkage. These results indicated that the direction of influence, at a physiological level, was predominantly from the person leading the conversation to the person listening. It was argued that the experimental manipulation of asking each spouse to listen empathically to their partner produced these outcomes for physiological linkage. Overall, these results provided substantial support for the first hypothesis that physiological linkage would occur during the expression of neutral, positive, and negative affect.

Physiological linkage was found to be reliably associated with perspective-taking (hypothesis 2). Significant outcomes emerged for all discussion segments and physiological linkage accounted for up to 55% of the variance in perspective-taking. The strongest and most consistent results were found between the ODPT scales and physiological linkage. This suggested that partner ratings of perspective-taking may be more reliable in studies of dyads than self ratings of perspective-taking.

Physiological linkage was also predictive of marital satisfaction (hypothesis 3). Significant relationships were found between physiological linkage during all discussion segments and each measure of marital satisfaction (KMSS and QMI). Physiological linkage was found to account for up to 51% of the variance in marital satisfaction. This level of prediction is similar to the finding of Levenson and Gottman (1983) that physiological linkage accounted for 60% of the variance in marital satisfaction for distressed couples engaged in conflict resolution. The results for the current research were extended to the expression of neutral, happy, and negative affect for non-distressed couples engaged in empathic listening.

Overall there was a high level of consistency in the results for physiological linkage with perspective-taking and marital satisfaction. This consistency suggested that, when physiological linkage is measured in an empathic context, physiological linkage may provide an index of the level of empathic listening skills in dyadic relationships.

The hypothesis that perspective-taking would be positively correlated with marital satisfaction was also supported (hypothesis 4). The strongest relationships were found for the ODPT scales. This result in conjunction with the finding of stronger relationships between physiological linkage and the ODPT scales provides additional support that partner ratings of perspective-taking may be more reliable than self ratings of perspective-taking.

The consistency of results for the presence and direction of physiological linkage, and relationships between physiological linkage and outcome variables provided substantive support for the suggestion that empathic listening mediated physiological linkage. The consistency of results also provided support for the proposed three stage model of empathy and that, in the context of empathic listening, physiological linkage most likely signified the feeling component of empathy. As physiological linkage also occurs in the context of distress, and the reciprocity of negative affect, caution is warranted when interpreting the meaning of physiological linkage.

Some suggestions for future research were provided, including refinements to the methodology used for the current research. These proposed changes in methodology may improve the evaluation of affective content for discussion segments and provide further insight into the salience of negative affect during empathic couple interactions.

Overall, the results of this research supported the position that, during empathic couple interactions, physiological linkage occurs as a result of empathic listening and signifies the feeling component of empathy.

References

References

Allison, P. D., & Liker, J. K. (1982). Analyzing sequential categorical data on dyadic interaction: A comment on Gottman. *Psychological Bulletin, 91,* 393-403.

Andreassi, J. L. (1995). *Psychophysiology: Human behavior and physiological response* (3rd ed.). Hillside, New Jersey: Lawrence Erlbaum Associates.

Aylsbery, L. J., & Marie, G. V. (1984). A system for monitoring the radial pulse: Application to pulse transit time measurement. *Psychophysiology, 21*, 558-561.

Barry, R. J., & Mitchell, F. H. (1987). A comparison of phasic cardiac response derived from the electrocardiograms and the peripheral pulse. *International Journal of Psychophysiology, 5,* 73-78.

Batson, C. D. (1991). *The altruism question.* New Jersey: Lawrence Erlbaum Associates.

Batson, C. D., O'Quin, K., Fultz, J., Vanderplas, M., & Isen, A. M. (1983). Influence of self-reported distress and empathy on egoistic versus altruistic motivation to help. *Journal of Personality and Social Psychology, 45,* 706-718.

Benjamin, L. S. (1967). Facts and artifacts in using analysis of covariance to "undo" the law of initial values. *Psychophysiology, 4,* 433-443.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review, 98,* 459-487.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Cardiac psychophysiology and autonomic space in humans: Empirical perspectives and conceptual implications. *Psychological Bulletin, 114,* 296-322.

Berntson, G. G., Cacioppo, J. T., Quigley, K. S., & Fabro, V. T. (1994). Autonomic space and psychophysiological response. *Psychophysiology, 31,* 44-61.

Berntson, G. G., Uchino, B. N., & Cacioppo, J. T. (1994). Origins of baseline variance and the law of initial values. *Psychophysiology, 31,* 204-210.

Block, J. D., & Bridger, W. H. (1962). The law of initial value in psychophysiology: A reformulation in terms of experimental and theoretical considerations. *Annals of the New York Academy of Sciences, 98,* 1229-1241.

Bolton, R. (1987). *People skills.* NSW: Simon and Shuster Australia.

Borke, H. (1971). Interpersonal perception of young children. *Developmental Psychology, 5*, 263-269.

Bourne, E. J. (1990). *The anxiety and phobia workbook.* Oakland: New Harbinger Publications.

Box, G. E. P., & Jenkins, G. M. (1976). *Time series analysis: Forecasting and control.* San Francisco: Holden Day.

Brandt, E. N., Jr. (1962). Gastric secretion and the law of initial value. *Annals of the New York Academy of Sciences, 98,* 1291-1295.

Bunnell, D. E. (1980). T-wave amplitude and the p-q interval: Relationships to non invasive indices of myocardial performance. *Psychophysiology, 17,* 592-597.

Bunnell, D. E. (1982). Autonomic myocardial influences as a factor determining inter-task consistency of heart rate reactivity. *Psychophysiology, 19,* 442-448.

Canfield, K. R., Schumm, W. R., Swihart, J. J., & Eggerichs, E. E. (1990). Factorial validity of brief satisfaction scales in surveys of Mormon, Roman Catholic, and Protestant fathers. *Psychological Reports, 67,* 1319-1322.

Chlopan, B. E., McCain, M. L., Carbonell, J. L., & Hagen, R. L. (1985). Empathy: Review of available measures. *Journal of Personality and Social Psychology, 31,* 349-360.

Cinciripini, P. M., & Epstein, L. H. (1981). Pulse transit time feedback and bidirectional blood pressure change. *Psychophysiology, 18,* 630-634.

Cleary, P. J. (1986). L.I.V. R.I.P.? Comments on Myrtek and Foerster's 'the law of initial value: A rare exception.' *Biological Psychology, 22,* 279-284.

Craske, M. G., & Barlow, D. H. (1993). Panic disorder and agoraphobia. In D. H. Barlow (Ed.), *Clinical handbook of psychological disorders* (2nd ed.). New York: Guildford Press.

Cross, D. G., & Sharpley, C. F. (1982). Measurement of empathy with the Hogan empathy scale. *Psychological Reports, 50,* 62.

Davis, M. H. (1983a). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology, 44,* 113-126.

Davis, M. H. (1983b). The effects of dispositional empathy on emotional reactions and helping: A multidimensional approach. *Journal of Personality, 51,* 167-184.

Davis, M. H., & Oathout, H. A. (1987). Maintenance of satisfaction in romantic relationships: Empathy and relational competence. *Journal of Personality and Social Psychology, 53,* 397-410.

Davis, M. H., & Oathout, H. A. (1992). The effect of dispositional empathy on romantic relationship behaviors: Heterosexual anxiety as a moderating influence. *Personality and Social Psychology Bulletin, 18,* 76-83.

Deutsch, F., & Madle, R. A. (1975). Empathy: Historic and current conceptualizations, measurement, and a cognitive theoretical perspective. *Human Development, 18,* 267-287.

DiMascio, A., Boyd, R. W., & Greenblatt, M. (1957). Physiological correlates of tension and antagonism during psychotherapy. *Psychosomatic Medicine, 14,* 99-104.

Dittes, J. E. (1957). Galvanic skin response as a measure of patient's reaction to therapist permissiveness. *Journal of Abnormal and Social Psychology, 55,* 295-303.

Ditto, B. (1987). Sibling similarities in cardiovascular reactivity to stress. *Psychophysiology, 24,* 353-360.

Ditto, B., Miller, S. B., Barr, R. G. (1998). A one-hour active coping stressor reduces small bowel transit time in healthy young adults. *Psychosomatic Medicine, 60,* 7-10.

Duan, C., & Hill, C. E. (1996). The current state of empathy research. *Journal of Counseling Psychology, 43*, 261-274.

Egan, G. (1994). *The skilled helper* (5th ed.). Pacific Grove: Brooks/Cole Publishing Company.

Eisenberg, N., Fabes, R. A., Miller, P. A., Fultz, J., Shell, R., Mathy, R. M., & Reno, R. R. (1989). Relation of sympathy and personal distress to prosocial behavior: A multidimensional study. *Journal of Personality and Social Psychology, 57,* 55-66.

Eisenberg, N., Fabes, R. A., Murphy, B., Karbon, M., Maszk, P., Smith, M., O'Boyle, C., & Suh, K. (1994). The relations of emotionality and regulation to dispositional and situational empathy-related responding. *Journal of Personality and Social Psychology, 66,* 776-797.

Eisenberg, N., Fabes, R. A., Murphy, B., Karbon, M., Smith, M., & Maszk, P. (1996). The relations of children's dispositional empathy-related responding to their emotionality, regulation, and social functioning. *Developmental Psychology, 32,* 195-209.

Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin, 101*, 91-119.

Eisenberg, N., Murphy, B. C., & Shepard, S. (1997). The development of empathic accuracy. In W. Ickes (Ed.), *Empathic accuracy* (pp. 73-116) New York: The Guildford Press.

Ekman, P., Levenson, R. W., & Frieson, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221,* 1208-1210.

Fahrenberg, J., Foerster, F., & Wilmers, F. (1995). Is elevated blood pressure level associated with higher cardiovascular responsiveness in laboratory tasks and with response specificity? *Psychophysiology, 32,* 81-91.

Feshbach, N. A., & Feshbach, S. (1969). The relationship between empathy and aggression in two age groups. *Developmental Psychology, 1,* 102-107.

Fincham, F. D., & Bradbury, T.N. (1987). The assessment of marital quality: A reevaluation. *Journal of Marriage and the Family, 49,* 797-809.

Furedy, J. J., & Scher, H. (1988). The law of initial values: Differentiated testing as an empirical generalization versus enshrinement as a methodological rule. *Psychophysiology, 26,* 120-122.

Geenen, R., & Van de Vijver, F. J. R. (1993). A simple test of the Law of Initial Values. *Psychophysiology, 30,* 525-530.

Gladstein, G. A. (1984). The historical roots of contemporary empathy research. *Journal of the History of the Behavioral Sciences, 20,* 38-59.

Goldwater, B. C. (1978). Effects of physical activity on initial level and response magnitude: An experimental study of the LIV. *Biological Psychology, 7,* 125-138.

Golland, J. H. (1981). Empathy as teachable. *American Psychologist, 36,* 225.

Gottman, J. (1997). *Why marriages succeed or fail.* London: Bloomsbury.

Gottman, J. M. (1979). Detecting cyclicity in social interaction. *Psychological Bulletin, 86,* 338-348.

Gottman, J. M. (1981). *Time-series analysis: A comprehensive introduction for social scientists.* Cambridge England: Cambridge University Press.

Gottman, J. M., Ringland, J. T. (1981). The analysis of dominance and bidirectionality in social development. *Child Development, 52,* 393-412.

Greenblatt, M. (1972). Two hearts in three-quarter time: Psychosomatic issues in a study of the psychophysiology of the psychotherapeutic interview. *Psychiatric Annals, 2*, 6-11.

Greenson, R. R. (1960). Empathy and its vicissitudes. *International Journal of Psychoanalysis, 41*, 418-424.

Grover, K. J., Paff-Bergen, L. A., Russell, C. S., & Schumm, W. R. (1984). The Kansas marital satisfaction scale: A further brief report. *Psychological Reports, 54,* 629-630.

Groves, P. M., & Rebec, G. V. (1992). *Biological psychology* (4th ed.) Iowa: Wm. C. Brown Publishers.

Gruen, R. J., & Mendelsohn, G. (1986). Emotional responses to affective displays in others: The distinction between empathy and sympathy. *Journal of Personality and Social psychology, 51,* 609-614.

Hallenback, P. N. (1981). A reply to Clark's "empathy". *American Psychologist, 36,* 225-226.

Heath, H. A., & Oken, D. (1962). Change scores as related to initial and final levels. *Annals of the New York Academy of Sciences, 98,* 1242-1256.

Hickson, J. (1985). Psychological research on empathy: In search of an elusive phenomenon. *Psychological Reports, 57,* 91-94.

Hodapp, V., Heiligtag, U., & Störmer, W. (1990). Cardiovascular reactivity, anxiety and anger during perceived controllability. *Biological Psychology, 30,* 161-170.

Hoffman, M. L. (1976). Empathy, role taking, guilt, and the development of altruistic motives. In T. Lickona (Ed.), *Moral development and behavior* (pp.124-143). New York: Holt, Rinehart and Winston.

Hoffman, M. L. (1990). Empathy and justice motivation. *Motivation and Emotion, 14*, 151-171.

Hogan, R. (1969). Development of an empathy scale. *Journal of Consulting and Clinical Psychology, 33,* 301-316

Hogan, R. (1973). Moral conduct and moral character: A psychological perspective. *Psychological Bulletin, 79*, 217-232.

Hord, D. J., Johnson, L. C., & Lubin, A. (1964). Differential effect of the law of initial value (LIV) on autonomic variables. *Psychophysiology, 1,* 79-87.

JaJeong, G., Bollman, S. R., & Schumm, W. R. (1992). Self-reported marital instability as correlated with the Kansas marital satisfaction scale for a sample of midwestern wives. *Psychological Reports, 70,* 243-246.

Jamieson, J. (1993). The law of initial values: Five factors or two? *International Journal of Psychophysiology, 14,* 233-240.

Jamieson, J. (1995). Measurement of change and the law of initial values: A computer simulation study. *Educational and Psychological Measurement, 55,* 38-46.

Jamieson, J., & Howk, S. (1992). The law of initial values: A four factor theory. *International Journal of Psychophysiology, 12,* 53-62.

Jennings, J. R. (1982). Beat-by-beat vascular responses during anticipatory heart rate deceleration. *Physiological psychology, 10,* 442-430.

Jennings, J. R., Van der Molen, M. W., & Brock, K. (1990). Forearm, chest, and skin vascular changes during simple performance tasks. *Biological Psychology, 31,* 23-45.

Jin, P. (1992). Toward a reconceptualization of the law of initial value. *Psychological Bulletin, 111,* 176-184.

Johnston, D. W., Anastasiades, P., & Wood, C. (1990). The relationship between cardiovascular responses in the laboratory and in the field. *Psychophysiology, 27,* 34-44.

Kaplan, H. B., Burch, N. R., & Bloom, S. W. (1964). Physiological covariation and sociometric relationships in small peer groups. In P. H. Leiderman, & D. Shapiro (Eds.), *Psychobiological approaches to social behavior.* Stanford, CA: Stanford University Press.

Kaplan, B. J., Whitsett, S. F., & Robinson, J. W. (1990). Menstrual cycle phase is a potential confound in psychophysiology research. *Psychophysiology, 27,* 445-450.

Kendall, M. G., & Stuart, A. (1967). *The advanced theory of statistics.* (Vol. 2, 2nd ed.) London: Griffin.

Koriath, J. K., & Lindholm, E. (1986). Cardiac-related cortical inhibition during a fixed foreperiod reaction time task. *International Journal of Psychophysiology, 4,* 183-195.

Lacey, J. I. (1956). The evaluation of autonomic responses: Towards a general solution. *Annals of the New York Academy of Sciences, 67,* 123-163.

Lacey, J. I. (1959). Psychophysiological approaches to the evaluation of psychotherapeutic process and outcome. In E. A. Rubinstein, & M. R. Parloff (Eds.), *Research in psychotherapy* (pp. 160-208). Washington, DC: American Psychological Association.

Lacey, J. I., & Lacey, B. C. (1962). The law of initial value in the longitudinal study of autonomic constitution: Reproducibility of the autonomic responses and response patterns over a four year interval. *Annals of the New York Academy of Sciences, 98,* 1257-1295.

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology, 45,* 587-597.

Levenson, R. W., & Gottman, J. M. (1985). Physiological and affective predictors of change in relationship satisfaction. *Journal of Personality and Social Psychology, 49,* 85-94.

Levenson, R. W., & Ruef, A. M. (1992). Empathy: A physiological substrate. *Journal of Personality and Social Psychology, 63,* 234-246.

Levenson, R. W., & Ruef, A. M. (1997). Physiological aspects of emotional knowledge and rapport. In W. Ickes (Ed.), *Empathic accuracy* (pp. 44-72). New York: The Guildford Press.

Light, K. C., & Obrist, P. A. (1980). Cardiovascular response to stress: Effects of opportunity to avoid, shock experience, and performance feedback. *Psychophysiology, 17,* 243-252.

Linden, W., & Estrin, R. (1988). Computerised cardiovascular monitoring: Method and data. *Psychophysiology, 25,* 227-234.

Llabre, M. M., Spitzer, S. B., Saab, P. G., Ironson, G. H., & Schneiderman, N. (1991). The reliability and specificity of delta versus residualized change as measures of cardiovascular reactivity to behavioral challenges. *Psychophysiology, 28,* 701-711.

Lo, C. R., & Johnston, D. W. (1984). Cardiovascular feedback during dynamic exercise. *Psychophysiology, 21,* 199-206.

Locke, H. J., & Wallace, K. L. (1959). Short marital-adjustment and prediction tests: Their reliability and validity. *Marriage and Family Living, 21,* 251-255.

Long, E. C. J. (1990). Measuring dyadic perspective-taking: Two scales for assessing perspective-taking in marriage and similar dyads. *Educational and Psychological Measurement, 50,* 91-103.

Long, E. C. J. (1993). Maintaining a stable marriage: Perspective taking as a predictor of a propensity to divorce. *Journal of Divorce and Remarriage, 21,* 121-138.

Long, E. C. J., & Andrews, D. W. (1990). Perspective taking as predictor of marital adjustment. *Journal of Personality and Social Psychology, 59,* 126-131.

Lovallo, W., Parsons, O. A., & Holloway, F. A. (1973). Autonomic arousal in normal, alcoholic, and brain-damaged subjects as measured by the plethysmograph response to cold pressor stimulation. *Psychophysiology, 10,* 166-176.

Lovallo, W., & Zeiner, A. R. (1974). Cutaneous vasomotor responses to cold pressor stimulation. *Psychophysiology, 11,* 458-471.

Lovallo, W., & Zeiner, A. R. (1975). Some factors influencing the vasomotor response to cold pressor stimulation. *Psychophysiology, 12,* 499-505.

Lykken, D. (1968). Neurophysiology and psychophysiology in personality research. In E. F. Borgatta, & W. W. Lambert (Eds.), *Handbook of personality theory and research.* Chicago: Rand McNally.

MacLagan, W. G. (1960). Respect for persons as a moral principle: Part 1. *Philosophy, 35,* 193-217.

MacLean, P. D. (1990). *The triune brain in evolution.* New York: Plenum Press.

Malmo, R. B., Boag, T. J., & Smith, A. A. (1957). Physiological study of personal interaction. *Psychosomatic Medicine, 12,* 105-119.

Marie, G. V., Lo, C. R., Van Jones, J., & Johnston, D. W. (1984). The relationship between arterial blood pressure and pulse transit time during dynamic and static exercise. *Psychophysiology, 21,* 521-527.

Markway, B. G., Carmin, C. N., Pollard, C. A., & Flynn, T. (1993). *Dying of embarrassment.* Oakland: New Harbinger Publications.

Martin, J. E., Epstein, L. H., & Cinciripini, P. M. (1980). Effects of feedback and stimulus control on pulse transit time discrimination. *Psychophysiology, 17,* 431-436.

McCarron, L. T., & Appel, V. H. (1971). Categories of therapist verbalizations and patient-therapist autonomic response. *Journal of Consulting and Clinical Psychology, 37*, 123-134.

Mehrabian, A., & Epstein, N. (1972). A measure of emotional empathy. *Journal of Personality, 40,* 525-543.

Mitchell, S. E., Newell, G. K., & Schumm, W. R. (1983). Test-restest reliability of the Kansas marital satisfaction scale. *Psychological Reports, 53,* 545-546.

Mock, D. C. (1962). The effects of the law of initial value on drug-induced diuresis. *Annals of the New York Academy of Sciences, 98,* 1296-1301.

Morell, M. A. (1989). Psychophysiologic stress responsivity in Type A and B female college students and community women. *Psychophysiology, 26,* 359-368.

Moser, R. S. (1984). The measurement of role taking in young adults. *Journal of Personality Assessment, 48,* 380-387.

Myrtek, M., & Foerster, F. (1986a). The law of initial value: A rare exception. *Biological Psychology, 22,* 227-237.

Myrtek, M., & Foerster, F. (1986b). Rejoinder to Cleary's "comments on Myrtek and Foerster's 'the law of initial value: A rare exception.'" *Biological Psychology, 22,* 285-287.

Norton, R. (1983). Measuring marital quality: A critical look at the dependent variable. *Journal of Marriage and The Family, 45,* 141-151.

Notarius, C. I., & Herrick, L. R. (1989). The psychophysiology of dyadic interaction. In H. Wagner, & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 393-419). Chichester, England: John Wiley & Sons.

Obrist, P. A., Light, K. C., McCubbin, J. A., Hutcheson, J. S., & Hoffer, J. L. (1979). Pulse transit time: Relationship to blood pressure and myocardial performance. *Psychophysiology, 16,* 292-301.

Öhman, A., Nordby, H., & Svebak, S. (1989). Components of Type A behavior and task-induced cardiovascular activation. *Psychophysiology, 26,* 81-88.

Oliver, R. G. (1975). Knowing the feelings of others. A requirement for moral education. *Education Theory, 25,* 116-124.

Redman, S., & Dutch, J. (1983). Classical conditioning of arterial pulse transit time and ECG-initiated transit time with the cold pressor as unconditioned stimulus. *Physiological Psychology, 11,* 87-90.

Redman, S., & Dutch, J. (1984). Arterial pulse transit time and ECG-initiated transit time: The form of conditioned responses. *Physiological Psychology, 12,* 213-216.

Robinson, J. W., Herman, A., & Kaplan, B. J. (1982). Autonomic responses correlate with counsellor-client empathy. *Journal of Counseling Psychology, 29,* 195-198.

Robinson, J. W., & Kaplan, B. J. (1985). Counselling psychology and psychophysiology: The neglected interface. *Canadian Counsellor, 3,* 82-97.

Roessler, R., Bruch, H., Thum, L., & Collins, F. (1975). Physiologic correlates of affect during psychotherapy. *American Journal of Psychotherapy, 29,* 26-37.

Rogers, C. R. (1959). A theory of therapy, personality and interpersonal relationships as developed in the client-centred framework. In S. Koch (Ed.), *Psychology: A study of a science: Vol. 3. Formulations of the person and the social context.* New York: McGraw-Hill.

Rogers, C. R. (1980). Empathic: An unappreciated way of being. In C. R. Rogers, *A way of being*. Boston: Houghton Mifflin.

Sabatelli, R. M. (1988). Measurement issues in marital research: A review and critique of contemporary survey instruments. *Journal of Marriage and the Family, 50,* 891-915.

Schectman, K. L., Bergen, M. B., Schumm, W. R., Bugaighis, M. A. (1985). Characteristics of the Kansas marital satisfaction scale among female participants in community childbirth education classes. *Psychological Reports, 56,* 537-538.

Schumm, W. R., Anderson, S. A., Benigas, J. E., McCutchen, M. B., Griffin, C. L., Morris, J. E., & Race, G. S. (1985). Criterion-related validity of the Kansas marital satisfaction scale. *Psychological Reports, 56,* 719-722.

Schumm, W. R., Nichols, C. W. Schectman, K. L., & Grigsby, C. C. (1983). Characteristics of responses to the Kansas marital satisfaction scale by a sample of 84 married mothers. *Psychological Reports, 53,* 567-572.

Schumm, W. R., Paff-Bergen, L. A., Hatch, R. C., Obiorah, F. C., Copeland, J. M., Meens, L. D., & Bugaihis, M. A. (1986). Concurrent and discriminant validity of the Kansas marital satisfaction scale. *Journal of Marriage and The Family, 48,* 381-387.

Schumm, W. R., Scanlon, E. D., Crow, C. L., Green, D. M., Buckler, D. L. (1983). Characteristics of the Kansas marital satisfaction scale in a sample of 79 married couples. *Psychological Reports, 53,* 583-588.

Schumm, W. R., & Silliman, B. (1996). Gender and marital satisfaction: A replication with a sample of spouses from the Christian church (disciples of Christ). *Psychological Reports, 79,* 496-498.

Smither, S. (1977). A reconsideration of the developmental study of empathy. *Human Development, 20,* 253-276.

Spanier, G. (1976). Measuring dyadic adjustment: New scales for assessing the quality of marriage and similar dyads. *Journal of Marriage and the Family, 38,* 15-28.

Stemmler, G. (1989). The autonomic differentiation of emotions revisited: Convergent and discriminant validation. *Psychophysiology, 26,* 617-632.

Steptoe, A. (1976). Blood pressure control: A comparison of feedback and instructions using pulse wave velocity measurements. *Psychophysiology, 13,* 528-535.

Steptoe, A. (1977). Voluntary blood pressure reductions measured with pulse transit time: Training conditions and reactions to mental work. *Psychophysiology, 14,* 492-498.

Steptoe, A. (1978). The regulation of blood pressure reactions to taxing conditions using pulse transit time feedback and relaxation. *Psychophysiology, 15,* 429-438.

Steptoe, A., & Ross, A. (1981). The analysis of behavioural control over cardiovascular activity using pulse transit time methodology. *Physiology and Behavior, 26,* 927-933.

Steptoe, A., & Ross, A. (1982). Voluntary control of cardiovascular reactions to demanding tasks. *Biofeedback and Self-Regulation, 7,* 149-166.

Steptoe, A., Smulyan, H., & Gribbin, B. (1976). Pulse wave velocity and blood pressure change: Calibration and applications. *Psychophysiology, 13,* 488-493.

Stern, R. M., Ray, W. J., & Davis, C. M. (1980). *Psychophysiological recording.* New York: Oxford University Press.

Sternbach, R. A (1966). *Principles of psychophysiology.* London: Academic Press.

Stotland, E. (1969). Exploratory investigations of empathy. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 271-314). San Diego CA: Academic Press.

Surwillo, W. W., & Arenberg, D. L. (1965). On the law of initial value and the measurement of change. *Psychophysiology, 1,* 368-370.

Svebak, S., Nordby, H., & Öhman, A. (1987). The personality of the cardiac responder: Interaction of seriousmindedness and Type A behavior. *Biological Psychology, 25,* 1-9.

Snyder, D. K. (1979). Multidimensional assessment of marital satisfaction. *Journal of Marriage and the Family, 41,* 813-823.

Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistics* (2nd ed.). New York: Harper Collins.

Thompson, R. (1987). Empathy and emotional understanding: The early development of empathy. In N. Eisenberg, & J. Strayer (Eds.), *Empathy and its development* (pp. 119-145). Cambridge England: Cambridge University Press.

Toon, P. D., Bergel, D. H., & Johnston, D. W. (1984). The effect of modification of baroreceptor activity on reaction time. *Psychophysiology, 21,* 487-493.

Tronnick, E. D., Als, H., & Brazelton, T. B. (1977). Mutuality in mother-infant interaction. *Journal of Communication, 27,* 74-79.

Vasey, M. W., & Thayer, J. F. (1987). The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. *Psychophysiology, 24,* 479-486.

Ungerer, J. A., Dolby, R., Waters, B., Barnett, B., Kelk, N., & Lewin, V. (1990). The early development of empathy: Self-regulation and individual differences in the first year. *Motivation and Emotion, 14,* 93-106.

Wagner H. L., & Calam, R. M. (1988). Interpersonal psychophysiology and the study of the family. In H. L. Wagner (Ed.), *Social psychophysiology and emotion: Theory and applications.* New York: John Wiley and Sons Ltd.

Walsh, K. (1994). *Neuropsychology: A clinical approach* (3rd ed.). Singapore: Longman.

Wilder, J. (1962). Basimetric approach (law of initial value) to biological rhythms. *Annals of the New York Academy of Sciences, 98,* 1211-1220.

Wilder, J. (1967). *Stimulus and response: The law of initial value.* Bristol, England: Wright.

Williams, E. A., & Gottman, J. M. (1982). *A user's guide to the Gottman-Williams time-series analysis computer programs for social scientists.* New York: Cambridge University Press.

Wispe, L. (1986). The distinction between sympathy and empathy: To call forth a concept, a word is needed. *Journal of Personality and Social Psychology, 50,* 314-321.

Wolpe, J. (1958). *Psychotherapy by reciprocal inhibition.* California: Stanford University Press.

Wolpe, J. (1973). *The practice of behaviour therapy* (2nd ed.). New York: Pergamon Press Inc.

Wolpe, J. & Wolpe, D. (1988). *Life without fear.* Oakland: New Harbinger Publications.

Woodall, W. G., & Kogler-Hill, S. E. (1982). Predictive and perceived empathy as predictors of leadership style. *Perceptual and Motor Skills, 54,* 800-802.

Zahn-Waxler, C., & Radke-Yarrow, M. (1990). The origins of empathic concern. *Motivation and Emotion, 14*, 107-130.

Appendices

Appendix A

Program Specification For the Development of Sequential Physiological Data From Raw Data

This program specification outlines programming requirements to produce sequential data files from raw data files, where the sequential data are deviation scores from preceding baselines. The specification describes the structure of the input data file, the calculations required, and a proposed output data file format. In addition, some issues in data handling are highlighted to ensure that the program will cater for expected variations in input data files.

General Requirements

The general requirements of the program are outlined below. Specific detail is described in later sections.

Input file format. The format of the input file will be as follows.

1. Excel *text* file *Tab delimited.*
2. There will be 84 columns per file. At times some of the columns will be empty so the program needs to be able to handle empty columns.
3. The number of rows will vary from column to column. Depending on how the programming is tackled it may be required to count the number of rows per column.

Calculations required. The general calculations required are listed below.

1. Means and standard deviations for each of the first 24 columns.
2. Running averages are required for 12 columns. The user will define the time interval for running averages. This will typically be five or ten seconds. New columns containing the running averages will need to be compiled.
3. Deviation scores for data in 36 columns and for the running average columns developed in step 2.

Output required. The basic output requirements are as follows. A file or files containing the means and standard deviations for the first 24 columns of data is required. In addition, up to 48 sets of deviation scores are to be compiled as a single column of data. Each file will combine deviation scores for two columns. Each output file to be saved as a text file, Tab delimited, with three decimal places. Also required is a statement (on screen) of the number of data points in each of the deviation score output files. This is required for later bivariate analysis. It should be noted that occasionally some of the 84 columns in the input data file will be empty. To avoid divide by zero errors during program execution, it is essential that calculations for empty columns are not undertaken.

Input Data File Format and Programming Requirements

The proposed format for the input data file divides into three segments – baseline data, interaction data, and the pulse transmission time to finger (PTT) data. Each segment will now be described and the programming requirements for each segment will be outlined.

Baseline data. This segment comprises the first 24 columns as illustrated in Figure A1. Means and standard deviations for all 24 columns are required.

Interaction data. The structure of this data is shown in Figure A2. For this set of data, deviation scores are required using the general formula:

Deviation Score = $(x_i - M) / SD$, $i = 25 - 60$. The means and standard deviations to be used for these calculations are paired as follows: For column 25 data use the mean and standard deviation from column 1; for column 26 data use the mean and standard deviation from column 2. Continue in this manner until column 30 is reached which will be paired with column 6. Then columns 31 to 36 are also paired sequentially with columns 1 through to column 6. The pairings for columns 37 – 42 and 43 – 48 are columns 9 – 14. For columns 49 –54 and 55-60 the corresponding pairings are columns 17 – 22. In summary the paired columns are as follows:

Columns 25 – 30 Uses mean and standard deviation from columns 1 - 6

Columns 31 – 36 Uses mean and standard deviation from columns 1 – 6

Columns 37 – 42 Uses mean and standard deviation from columns 9 – 14

Columns 43 – 48 Uses mean and standard deviation from columns 9 – 14

Columns 49 – 54 Uses mean and standard deviation from columns 17 – 22

Columns 55 – 60 Uses mean and standard deviation from columns 17 – 22

Please note that columns 7, 8, 15, 16, 23, and 24 are not used at this stage. The outcome of the calculations is the development of a new set of sequential deviation score data for heart rate, skin conductance and finger pulse amplitude.

Pulse transmission time data. This data needs to be dealt with in two stages. First, running averages are required for pulse transmission time data (columns 61 – 84). Then sequential deviation scores will be developed from the running averages. The user will define the interval for the running averages (typically five seconds). The structure of the pulse transmission time segment of the data file is shown in Figure A3. Note that the timing information, for when each pulse transmission time occurred, is in the column to the left of the value of pulse transmission time. Thus, the timing and value column pairs are as follows: (61 , 62), (63 , 64), (65 , 66), (67 , 68), (69 , 70), (71 , 72), (73 , 74), (75 , 76), (77 , 78), (79 , 80), (81 , 82), (83 ,84). When calculating the running averages the timing information needs to be used to determine the number of terms to be included in each average. Also note that the averages are to be computed in pairs. For example, when working with data from columns 61 – 64 each pair (62 , 64) will have the same start time (in columns 61 and 63). Additionally, it should be noted that adjacent pairs of data (e.g., 61 – 64 versus 65 – 68) could have different start times. Thus, the program will need to read the start time for each set of four columns (e.g., columns 61 and 63). Then, count up to the user defined timing interval separately for each column (e.g., 61 and then 63) to determine the number of terms to be averaged (e.g., in columns 62 and 64). These calculations will provide sequential sets of pulse transmission time data for the specified intervals.

Proposed Output Files Format

The sequential deviation data files produced by the program are to be analysed by a DOS based bivariate statistics program. For ease of file identification, and transfer of data to this program, a preferred file format for the sequential deviation score data will be outlined. For the means and standard deviation data (columns 1 – 24) one file containing all the means and another for the standard deviations would be appropriate.

The number and format of output files. For simplicity it may be easier to set up all output files as a single column, text, Tab delimited, three decimal places. For the basic means and standard deviations two files labelled 'means' and 'standard deviation' (or SD) would suffice. For the sequential deviation data files up to 48 output files are required.

Composition of files. For the means and standard deviation files (one for each) a sequential arrangement where the first number is the mean (or standard deviation) for column one, the second number the mean for column two and so on to column 24 would be easy to read. For columns that do not contain data insert zero (or another character) to avoid errors in interpretation. For the sequential deviation data files each file will combine two columns of deviation data into a single column. The references provided here will be the original input file data column numbers. Therefore, when writing the program a one to one correspondence between the original data column and the deviation score data developed from that column will need to be preserved. The pairings for the interaction data columns (columns 25 – 60) are (25 , 26), (27 , 28), (59 , 60). For the PTT data (columns 61 – 84) the pairings are (62 , 64), (66, 68), (70 , 72), (74 , 76), (78 , 80). In all cases the first reference will be at the top of the data column.

Names of output data files. The simple means and standard deviation files have been covered. However, the sequential deviation data files require careful naming. First, as the bivariate programs, that will use these files as input, are DOS based the file name can have a maximum of eight characters. Also, as the bivariate programs expect a text file, a text extension (.txt) is required for each deviation data file. The general structure of the output file names will be described followed by specific details of how to allocate particular file character positions. For characters one and two use the couple number that is input by the user at the beginning. A range from 00 to 99 will be adequate. Characters three and four will be either FL or ML (female lead or male lead). Character five will be N, H, or C (neutral, happy, or conflict). Characters five to eight will be HR, SCL, FPA or PTT (heart rate, skin conductance level, finger pulse amplitude, or pulse transmission time). With this system the character positions three to eight are dependent on the columns in the input data file from which the deviation scores were developed. For characters three, four, and five, selection will be as follows:

1. MLN corresponds to columns 25-30, 62 and 64.
2. FLN corresponds to columns 31-36, 66 and 68.
3. MLH corresponds to columns 37-42, 70 and 72.
4. FLH corresponds to columns 43-48, 74 or 76.
5. MLC corresponds to columns 49-54, 78 or 80.
6. FLC corresponds to columns 55-60, 82 or 84.

For characters six, seven, and eight, selection will be as follows: HR corresponds to columns (25 , 26), (31 , 32), (37 , 38), (43 , 44), (49 , 50), (55 , 56); SCL corresponds to columns (27 , 28), (33 , 34), (39 , 40), (45 , 46), (51 , 52), (57 , 58); FPA corresponds to columns (29 , 30), (35 ; 36), (41 , 42), (47 , 48), (53 , 54), (59 , 60); and PTT corresponds to columns (62 , 64), (66 , 68), (70 , 72), (74 , 76), (78 , 80), (82 , 84).

Using this structure a typical output file could be 09FLHFPA.txt. This is data for couple 9, the female partner is leading the conversation, the topic is a happy event, and the physiological measure is finger pulse amplitude.

Interface of the Program to the User

For ease of use suggested features of how the program appears to the user and the facilities sought will now be discussed. A program that will function in a Windows environment and can be opened via double clicking an icon would be ideal. The user interface should provide an input window that seeks the number of the couple for which data is to be analysed and the time interval for the sequential averages. Ability to browse to locate the required input file would be an advantage versus having to supply the path information for the file location.

	Baseline data sections		
	Baseline neutral	Baseline happy	Baseline conflict
Column range	1-8	9-16	17-24

	Baseline neutral							
Measure	HR		SCL		FPA		PTT	
Gender	male	fem	male	fem	male	fem	male	fem
Column	1	2	3	4	5	6	7	8

	Baseline conflict							
Measure	HR		SCL		FPA		PTT	
Gender	male	fem	male	fem	male	fem	male	fem
Column	17	18	19	20	21	22	23	24

	Baseline happy							
Measure	HR		SCL		FPA		PTT	
Gender	male	fem	male	fem	male	fem	male	fem
Column	9	10	11	12	13	14	15	16

Figure A1. Breakdown of baseline segment of input data file (columns 1 – 24) for males and females (fem) across heart rate (HR), skin conductance level (SCL), finger pulse amplitude (FPA) and pulse transmission time to finger (PTT).

	Interaction data sections					
Interaction segment	Male lead neutral	Female lead neutral	Male lead happy	Female lead happy	Male lead conflict	Female lead conflict
Column range	25 -30	31 - 36	37 - 42	43 - 48	49 - 54	55 - 60

	Male lead neutral						Female lead neutral					
Measure	HR		SCL		FPA		HR		SCL		FPA	
Gender	male	fem	male	fem	male	fem	male	fem	male	fem	male	fem
Column	25	26	27	28	29	30	31	32	33	34	35	36

	Male lead happy						Female lead happy					
Measure	HR		SCL		FPA		HR		SCL		FPA	
Gender	male	fem	male	fem	male	fem	male	fem	male	fem	male	fem
Column	37	38	39	40	41	42	43	44	45	46	47	48

	Male lead conflict						Female lead conflict					
Measure	HR		SCL		FPA		HR		SCL		FPA	
Gender	male	fem	male	fem	male	fem	male	fem	male	fem	male	Fem
Column	49	50	51	52	53	54	55	56	57	58	59	60

Figure A2. Breakdown of interaction segment of input data file (columns 25 – 60) for males and females (fem) across heart rate (HR), skin conductance level (SCL), finger pulse amplitude (FPA) and pulse transmission time to finger (PTT), for the male and female leading the conversation.

	Pulse transmission time interaction data segments		
Segment	PTT neutral	PTT happy	PTT conflict
Columns	61 - 68	69 – 76	77 - 84

	Neutral: Pulse transmission time segment							
Interaction	Male lead neutral				Female lead neutral			
Gender	Male		Female		Male		Female	
Measure	time	value	time	value	time	value	time	value
Column	61	62	63	64	65	66	67	68

	Happy: Pulse transmission time segment							
Interaction	Male lead happy				Female lead happy			
Gender	Male		Female		Male		Female	
Measure	time	value	time	value	time	value	time	value
Column	61	62	63	64	65	66	67	68

	Conflict: Pulse transmission time segment							
Interaction	Male lead conflict				Female lead conflict			
Gender	Male		Female		Male		Female	
Measure	time	value	time	value	time	value	time	value
Column	61	62	63	64	65	66	67	68

Figure A3. Breakdown of pulse transmission time (PTT) interaction segments of input data file (columns 61 – 84) for males and females, indicating the time PTT was measured and the value of PTT, when the male and female led the conversation.

Appendix B

Protocols For the Current Research

Appendix B1: Participant Consent Form

Appendix B2: Kansas Marital Satisfaction Questionnaire (KMSS)

Appendix B3: Quality of Marriage Index (QMI)

Appendix B4: Self Dyadic Perspective-Taking Scale (SDPT)

Appendix B5: Other Dyadic Perspective-Taking Scale (ODPT)

Appendix B1: Participant Information Sheet and Consent Form.

A study is being conducted by John O' Mara and Dr. Iain Montgomery of the University of Tasmania in an attempt to understand how the thoughts, feelings and behaviours of married couples contribute to their level of marital satisfaction. As a participant in this study, you will be asked to answer questions relating to your marriage. In addition, measures of heart rate, blood flow, and skin conductance will be taken while you engage in discussions with your partner. In order to take these measurements, a number of electrodes will be attached to your body and non-dominant hand. Placement of these electrodes will produce minimal discomfort.

The study is conducted over a single session of 1.5 to 2 hours. During this session both you and your partner will be asked to take turns in relating to each other: (a) A neutral or boring story; (b) a happy event; and (c) a conflict with a third party. Participation in this study is entirely voluntary and you may withdraw from this study at any time, without prejudice, by stating that you wish to do so.

The information that you provide will be kept secure and confidential at all times. You will be compensated $30 for your time and travel expenses. If you have any questions or concerns about the study please contact John O' Mara or Dr. Iain Montgomery.

If you have any ethical concerns regarding the manner in which the research is being conducted please contact Dr. Margaret Otlowski or Ms Chris Hooper.

I have read the information about the study and any questions I have asked have been answered to my satisfaction. I agree to participate in this investigation and understand that I may withdraw at any time, without prejudice. I agree that research data gathered for the study may be published provided that I cannot be identified.

Name: ____

Address: ____

____

____

Phone: ____________________

Signature of participant:______________________________ Date: _______

I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that they understand the implications of participation.

Signature of investigator:______________________________ Date: _______

Appendix B2: Kansas Marital Satisfaction Questionnaire (KMSS).

Instructions.

Listed below are three questions about marriage. For each question please circle the answer that best describes your current level of satisfaction with your marriage and your relationship.

Item	Extremely Dissatisfied	Very Dissatisfied	Somewhat Dissatisfied	Mixed	Somewhat Satisfied	Very Satisfied	Extremely Satisfied
1. How satisfied are you with your marriage?	1	2	3	4	5	6	7
2. How satisfied are you with your partner as a spouse?	1	2	3	4	5	6	7
3. How satisfied are you with your relationship with your partner?	1	2	3	4	5	6	7

Appendix B3: Quality of Marriage Index (QMI).

Instructions.
Listed below are several statements about marriage. Please circle the number that best indicates your level of agreement with each statement.

Item	Strong Disagreement	Moderate Disagreement	Mild Disagreement	Neither Agree or Disagree	Mild Agreement	Moderate Agreement	Strong Agreement
1. We have a good marriage	1	2	3	4	5	6	7
2. My relationship with my partner is very stable	1	2	3	4	5	6	7
3. Our marriage is strong	1	2	3	4	5	6	7
4. My relationship with my partner makes me happy	1	2	3	4	5	6	7
5. I really feel like *part of a team* with my partner	1	2	3	4	5	6	7

Appendix B4: Self Dyadic Perspective-Taking Scale (SDPT).

Instructions.
How well do the following statements describe your behaviour and actions with your partner on a scale from 0 to 4, where 0 does not describe you very well and 4 describes you very well. Please circle the number that best describes you.

1.	I am good at understanding my partner's problems.	0	1	2	3	4
2.	I not only listen to my partner, but I understand what he/she is saying, and seem to know where he/she is coming from.	0	1	2	3	4
3.	I very often seem to know how my partner feels.	0	1	2	3	4
4	I always know exactly what my partner means.	0	1	2	3	4
5.	I am able to sense or realise what my partner is feeling.	0	1	2	3	4
6.	Before criticising my partner I try to imagine how I would feel in his/her place.	0	1	2	3	4
7.	I sometimes try to understand my partner better by imagining how things look from his/her perspective.	0	1	2	3	4
8.	In my relationship with my partner I believe that there are two sides to every question, and I try to look and think about both sides.	0	1	2	3	4
9.	I try to look at my partner's side of a disagreement before I make a decision.	0	1	2	3	4
10.	When I'm upset with my partner, I usually try to put myself in his/her shoes for a while.	0	1	2	3	4
11.	Even if my partner has difficulty in saying something, I usually understand what he/she means.	0	1	2	3	4
12.	I usually do not understand the full meaning of what my partner is saying to me.	0	1	2	3	4
13.	I am able to appreciate exactly how the things my partner experiences, feel to him/her.	0	1	2	3	4

Appendix B5: Other Dyadic Perspective-Taking Scale (ODPT).

Instructions.
How does your partner act towards you on a scale from 0 to 4, where 0 does not describe your partner very well and 4 describes your partner very well. Please circle the number that best describes your partner.

1.	When involved in an argument with me, my partner is the type of person who will consider and take into account my point of view and compare that with his/her own.	0 1 2 3 4
2.	My partner is not good at understanding my problems.	0 1 2 3 4
3.	My partner not only listens to what I am saying but really understands and seems to know where I am coming from.	0 1 2 3 4
4.	My partner does not seem to know how I feel.	0 1 2 3 4
5.	My partner is able to accurately compare his/her point of view with mine.	0 1 2 3 4
6.	My partner evaluates my motivation for doing something before he/she makes judgements about a situation.	0 1 2 3 4
7.	My partner easily becomes impatient with me.	0 1 2 3 4
8.	My partner is not able to put him/herself into my shoes.	0 1 2 3 4
9.	My partner nearly always knows exactly what I mean.	0 1 2 3 4
10.	My partner does not sense or realise what I am feeling.	0 1 2 3 4
11.	My partner realises what I mean even when I have difficulty saying it.	0 1 2 3 4
12.	My partner usually does not understand the whole meaning of what I say to him/her.	0 1 2 3 4
13.	My partner appreciates how the things I experience, feel to me.	0 1 2 3 4
14.	Before criticising me, my partner tries to imagine how I feel.	0 1 2 3 4
15.	If my partner thinks he/she is right about something he/she doesn't waste much time in listening to my arguments.	0 1 2 3 4
16.	My partner tries to understand me better by imagining how things look from my perspective.	0 1 2 3 4
17.	My partner believes that there are two sides to every argument and tries to look at both sides.	0 1 2 3 4
18.	My partner sometimes finds it difficult to see things from my perspective.	0 1 2 3 4
19.	My partner tries to look at my perspective before making a decision.	0 1 2 3 4
20.	When my partner is upset with me, he/she tries to put him/herself in my shoes for a while.	0 1 2 3 4