DYADIC INTERRELATIONS IN EMOTIONAL EXPERIENCES AMONG OLDER SPOUSES: ASSOCIATIONS WITH CONCURRENT AND LONGER-TERM CHANGES IN HEALTH

by

Victoria Izabela Michalowski

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Psychology)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

November 2020

The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, the dissertation entitled:

Dyadic interrelations in emotional experiences among older spouses: Associations with concurrent and longer-term changes in health

submitted by Victoria Izabela Michalowski in partial fulfillment of the requirements for

the degree of Doctor of Philosophy

in Psychology

Examining Committee:

Dr. Christiane A. Hoppmann, Department of Psychology, UBC
Supervisor

Dr. Anita DeLongis, Professor, Department of Psychology, UBC
Supervisory Committee Member

Dr. Peter Graf, Professor, Department of Psychology, UBC
Supervisory Committee Member

Dr. Frances Chen, Professor, Department of Psychology, UBC
University Examiner

Dr. Peter Crocker, Professor, Department of Kinesiology, UBC
University Examiner

Abstract

While links between emotional experiences and health are well-established, extant research is largely based on individuals and cross-sectional data, which is limiting given that emotional experiences are dynamic and interpersonal. In older age, emotional experiences are often maintained or improved relative to earlier life phases, due to adaptive emotion regulation strategies and motivational shifts in priorities. This dissertation aimed to identify socio-emotional pathways underlying health with aging, by taking both spousal perceptions and multiple time-scales into account. This research primarily used data from up to 119 older adult couples, who simultaneously completed 28 momentary assessments of affect and salivary cortisol over a 7-day period, and annual assessments of cardiovascular risk and environmental mastery over three years. Simultaneous assessments in daily life facilitated investigating emotion dynamics in a social context, and were further linked with processes that unfold over different timescales. Study 1 focused on the role of intraindividual affect variability in facilitating empathic accuracy. Older adults more accurately perceived the happiness of their spouse if they themselves were more variable in their happiness, whereas affect variability was unrelated to being read well. Findings replicated in a similar data set of older adult couples. Study 2 examined dyadic covariation in affect and the stress hormone cortisol to illuminate how emotional experiences 'get under the skin' in everyday settings. Changes in one's own affect corresponded with changes in one's own salivary cortisol. Changes in one's partner's affect were only associated with own salivary cortisol if the partner was perceived as having shared their feelings more than usual. Study 3 linked spousal fluctuations in affect with longitudinal physical and mental health indicators. Individual and spousal affect variability were negatively associated with concurrent and long-term health, as indicated by elevated pulse pressure for men and low environmental

mastery for women. Spouses sharing their feelings was generally beneficial for health. Taken together, this dissertation identifies key social dynamics in emotional experiences that shape health in older adult couples, pointing to the double-edged nature of spousal interrelations in emotional experiences for levels and changes in health in older adulthood.

Lay Summary

Emotions are dynamic, change when we are with close others, and are closely linked with physical and mental health. This dissertation uses data from two samples of older adult couples who provided several emotion ratings per day over 7 days, along with annual health assessments. Study 1 showed that individuals who fluctuate in their own happiness gauged the happiness of their partner more accurately. Study 2 found that stress hormones (e.g. cortisol) wax and wane not only with one's own emotions, but also with how one's spouse is feeling, although only if one's spouse is sharing their feelings. Study 3 connected short-term fluctuations in individual and spousal emotions with concurrent as well as longer-term health, although differentially for men and women. Findings across different timescales point to the role of the spouse in linkages between emotions and health in older adulthood.

Preface

Under the supervision of my advisor, Dr. Christiane Hoppmann, I was responsible for identifying and designing this PhD research program, for formulating its specific research questions, and for conducting all data analyses. I was the study coordinator of the core project outlined in this dissertation. The project is titled Linked Lives, and targeted spousal health dynamics in community-dwelling older adult couples residing in the Greater Vancouver Area. Christiane Hoppmann, Denis Gerstorf, Maureen Ashe, and Kenneth Madden were responsible for conceiving the Linked Lives project. I coordinated the project and was directly involved in collecting and processing the data. Cortisol data handling and cleaning procedures are published in the Oxford Research Encyclopedia of Psychology: *Hoppmann, C. A., Pauly, T., Michalowski, V. I., & Nater, U. M. (2018). Everyday salivary cortisol as a biomarker method in lifespan developmental methodology. In Oxford research encyclopedia of psychology. Oxford University Press*.

I am the primary author and contributor to this dissertation (Chapters 1-5). The conceptual model I developed for this dissertation focuses on interrelated health and well-being trajectories in aging couples. It is published in the Oxford Research Encyclopedia of Psychology: *Michalowski, V. I., Gerstorf, D., & Hoppmann, C. A. (2018) Aging couples: Benefits and costs of long intimate relations. In Knight, B. (Ed.), Oxford research encyclopedia of psychology. Oxford University Press.* Chapter 1 is partly based on this publication. I am first author of this publication, and was responsible for the literature review, formulating the conceptual model, and writing the first draft of the manuscript. Denis Gerstorf and Christiane Hoppmann contributed to revising the manuscript.

Chapter 2 is based on a published manuscript: *Michalowski, V. I., Gerstorf, D., Hueluer, G., Drewelies, J., Ashe, M. C., Madden, K. M., & Hoppmann, C. A. (2020). Intraindividual variability and empathic accuracy for happiness in older couples. GeroPsych. Advance online publication. http://dx.doi.org/10.1024/1662-9647/a000233.* This manuscript is based on data from the core Linked Lives project, and data from a sister project in Berlin, Germany (Berlin Couples Dynamics project; PI Gerstorf). I am the first author of this publication. I was responsible for developing the research questions, undertaking the literature review, conducting the statistical analyses, and writing the first draft of the manuscript. Denis Gerstorf, Gizem Hülür, Johanna Drewelies, Maureen Ashe, Kenneth Madden, and Christiane Hoppmann contributed to revising the manuscript. Chapters 3 and 4 are currently being prepared for publication, where I am first author, and responsible for developing the research questions, undertaking the literature reviews, conducting the statistical analyses, and writing the first draft of the manuscripts.

Ethics approval was granted for all research presented in this dissertation. The Linked Lives project (Chapters 2, 3, and 4) was approved by the Clinical Research Ethics Board of the University of British Columbia, #H12-01854. The Berlin Couples Dynamics project (Chapter 2) was approved by the research ethics board of the Humboldt University Berlin (#2013-15), and ethics approval for secondary data analysis was granted by the Behavioural Research Ethics Board of the University of British Columbia (#H18-01490).

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List of Abbreviations

APIM	Actor Partner Interdependence Model
b	Unstandardized Beta Slope
H	Husband
HPA	Hypothalamic Pituitary Adrenal
iSD	Intraindividual Standard Deviation
iMSSD	Intraindividual Mean Squared Successive Difference
M	Mean
N	Sample Size
SD	Standard Deviation
SE	Standard Error
T & B	Truth and Bias Model
T1	Time One
T2	Time Two
T3	Time Three
W	Wife

Acknowledgements

I would like to offer my sincere thanks to my supervisor, Dr. Christiane Hoppmann, for believing in my academic potential ever since I initially joined the lab as an undergraduate student. Under your guidance, I've experienced a wealth of opportunities and growth in my research training over the years, and I am forever grateful. I would also like to extend my thanks to my committee members, Drs. Anita DeLongis and Peter Graf, for challenging me with insightful and thoughtful feedback that has been instrumental in the development of my doctoral research. Additionally, I would like to express my appreciation for the collaborations I've been lucky to share in with Drs. Denis Gerstorf, Maureen Ashe, Kenneth Madden, Johanna Drewelies, and Gizem Hülür.

Special thanks to the students in the lab and wider department who have supported me, both professionally and personally. Thanks to Pavel Kozik, for partnering with me through many courses, teaching and research assistantships, and statistical consultations – I am lucky to have gone through graduate school with you. Thanks to Jennifer Lay, Ellen Stephenson, Jessica Pow, and Theresa Pauly for being the most inspiring colleagues and friends that I could have hoped for – I will always aspire to be as talented, generous, and kind as you. Thank you to my hard-working research assistants, who went above and beyond in helping with the Linked Lives study.

My deep thanks are owed to my family, who gave me purpose and perspective throughout my doctoral work – and probably learned more about health psychology and quantitative methods than they ever really wanted to. I would like to especially thank my parents for giving me every kind of helpful support and encouragement from the beginning, and my husband, Gordie, for being a profoundly positive force in my life.

I would like to gratefully acknowledge the doctoral funding I received from the University of British Columbia and the Social Sciences and Humanities Research Council of Canada (SSHRC). I am grateful for research funding from the Canadian Institutes of Health Research and the generous time given by research participants that made the Linked Lives study possible.

Chapter 1: Introduction

1.1 Emotional Experiences and Health

Emotional experiences are closely connected to physical and mental health (Pressman & Cohen, 2005; Watson, 1988). Negative affect has been traditionally focused on as a psychological culprit behind adverse outcomes, but with the positive psychology movement (Seligman et al., 2005), an emerging body of literature has systematically linked positive affect with both physical and mental health as well. For example, a review by Diener et al. (2017) outlines the links between subjective well-being and health. Other work by Sin and Lyubomirsky (2009) provides an overview of the benefits of positive psychology interventions (i.e. treatments or activities meant to build positive feelings, behaviors, or thoughts) for improved psychological well-being and reduced depressive symptomology. With regards to physical health, it has been suggested that positive affect is broadly beneficial (Cohen & Pressman, 2006; Pressman & Cohen, 2005), and more specifically linked with improved immune function (Marsland et al., 2007), positive health behaviour change (Van Cappellen et al., 2018), improved vagal tone (Kok et al., 2013), reduced risk of all-cause mortality (Petrie et al., 2018), lower ambulatory heart rate, lower cortisol levels (Steptoe et al., 2005), as well as accelerated physiological recovery from stress via faster skin wound (Robles et al., 2009) and cardiovascular recovery (Fredrickson & Levenson, 1998).

While positive affect and negative affect are distinct, they are not completely independent of each other. For example, the degree to which positive and negative affect are discrete constructs can depend on the time frame in question, with positive and negative affect inversely co-varying within moments or days, but showing greater independence from one another over time periods spanning weeks or longer (Diener & Emmons, 1984). In addition, there is some

evidence for discrete physiological effects of positive and negative affect, where compared to positive affect, negative affect is more strongly associated with heart rate and body temperature increases in both younger (Ekman et al., 1983) and older adults (Levenson et al., 1991). From a functionalist perspective, positive and negative affect likely serve different, yet equally important functions. While negative affect facilitates focused and immediate responses to threat, the Broaden and Build Theory (Fredrickson, 1998, 2001, 2004) suggests that positive affect serves to broaden cognitive-behavioural repertoires and ultimately build personal resources. Hence, it does not seem to be the case that one type of affect is more impactful for physical and mental health than the other. Rather that it may be useful to consider both as playing distinct roles for health with aging. The health-relevance of emotional experiences likely also depends on the timeframe.

Although many domains of functioning are vulnerable to decline with aging, it has been shown that emotional experience is generally maintained or improved until the 70s and sometimes beyond (Carstensen et al., 2000). This observation has been attributed to future time perspective-related shifts in goals and priorities that optimize emotional well-being (Carstensen et al., 2003; Carstensen et al., 1999), improved emotion regulation (Blanchard-Fields et al., 2004; Charles, 2010), and an avoidance of stressful encounters (Charles, 2010; Gross et al., 1997). Older adulthood may be characterized by better quality emotional experiences than young adulthood, but when older adults are confronted with a stressor, they respond at least as strongly as young adults (Graham et al., 2006; Uchino et al., 2010). According to the Strength and Vulnerability Integration model (SAVI; Charles, 2010), older adults are generally good at avoiding situations that elicit negative emotional experiences in everyday life (e.g. Brose et al., 2013; Charles et al., 2010), but when such situations do occur, they are physiologically more affected than younger adults (Graham et al., 2006; Uchino et al., 2010). Hence, while emotional

experiences in older adulthood seem to be more positive, older adults are particularly vulnerable to negative emotional experiences if a stressor cannot be avoided (Schilling & Diehl, 2014; Scott et al., 2017).

1.2 Short-Term Variability in Emotional Experiences and their Association with Concurrent as well as Longer-Term Changes in Health

When linking emotional experiences to health, emotional experiences are often operationally defined by their mean. Yet, emotional experiences are not static, and a recognition of the fluctuating nature of emotional experiences across different situations and time points represents an important extension in this dissertation. Changes in emotional experiences across a variety of everyday situations can be broadly conceptualized as 'affect variability' (Ram & Gerstorf, 2009). Intra-individual affect variability captures the ups and downs in an individual's affective state over several situations and time points, and reflects the degree to which one deviates from how they usually feel. Intra-individual differences in deviations from mean affect across different situations can ultimately be meaningful for intra-individual changes in physical and mental health (Ong & Ram, 2017; Hardy & Segerstorm, 2016). Generally, high affect variability (i.e. extreme fluctuations within a short span of time) is associated with worse physical and mental health, above and beyond average levels of affect (Ong & Ram, 2017).

What makes a person feel different from one point in time to another lies at the intersection of two distinct yet interrelated concepts: intra-individual variability and intra-individual change (Nesselroade, 1991). Intra-individual variability can be described as changes that fluctuate relatively quickly and are reversible (i.e. 'states' of being), while intra-individual change is accumulative, directional change that can be slower to revert back from (Nesselroade, 1991). Intra-individual variability is studied over short-term periods (e.g. minutes, hours, days),

while intra-individual change is examined over longer-term periods (e.g. months, years; Nesselroade, 1991; Ram & Gerstorf, 2009). Although intra-individual variability and longer-term change are conceptually distinct, they are woven together over the lifespan in shaping aging trajectories.

The most broadly used and intuitive operationalization of intra-individual affect variability is the intra-individual standard deviation (iSD; Ram & Gerstorf, 2009). Specifically, a standard deviation is computed for each individual, across all of their respective daily life affect ratings; a higher iSD value is interpreted as meaning that an individual characteristically deviates from their own mean affect level to a greater degree, relative to someone with a lower iSD value (Ram & Gerstorf, 2009). Another popular index of affect variability is the intra-individual mean squared successive difference (iMSSD), which has considerable overlap with the iSD, but captures variability as well as temporal dependency across assessment points (Ebner-Premier et al., 2007; Jahng et al., 2008). All analyses in this dissertation are primarily conducted with the iSD for interpretability purposes, but are re-examined using the iMSSD to determine the robustness of findings. Importantly, both indices are dependent on the intra-individual mean. It is therefore recommended to account for this dependency by modeling the intraindividual variability and intra-individual mean simultaneously (e.g. Jones et al., 2020; Koval et al., 2013). Conceptually, an advantage of this approach is that mean levels of emotional experiences, which are also relevant for physical and mental health, are taken into account.

Notably, there are a number of additional constructs that have been used to capture unique features of affective dynamics, such as affective reactivity (Charles et al., 2013; Piazza et al., 2013), instability (Ram & Gerstorf, 2009), or affective flux and spin (Moskowitz & Zuroff, 2004), to name a few. The current dissertation purposefully uses intraindividual variability as the

most inclusive indicator of affective dynamics because it captures ups and downs in response to a host of different daily life situations. Changes in affect from one moment to the next are not necessarily maladaptive, and can reflect a degree of flexibility in the face of changing circumstances (Levy-Gigi et al., 2016). For instance, it would be unusual and not useful to respond with the same affect to a funeral and to a party (Fleeson, 2004). However, fluctuations in affect that are large and frequent can co-occur with stress responses and may lead to bodily wear-and-tear (e.g. allostatic load model of stress; McEwen & Stellar, 1993; Seeman & Gruenwald, 2006). Conceptually, higher affect variability may reflect difficulty maintaining stable emotional responding to everyday circumstances, with lower affect variability in turn reflecting a maintenance of emotional 'homeostasis' and successful adaptation to everyday routines in healthy samples (Röcke & Brose, 2013). Hence, large and frequent deviations in affect from average levels may reflect prolonged disruption of resting homeostatic processes, in line with previous findings showing that greater intraindividual affect variability has maladaptive associations with physical and mental health (Hardy & Segerstorm, 2016).

The idea that fluctuating affect can be detrimental to mental health has also been recognized by the clinical psychological literature. Extremely high and low affect variability may respectively reflect mania or flat affect (Kuppens et al., 2007; Trull et al., 2008). For example, while both major depressive disorder and borderline personality disorder share high mean negative affect, borderline personal disorder is characterized by sudden, frequent, and large changes in affective responses to external stimuli (Trull et al., 2008). In non-clinical populations, high affect variability is conceptually and empirically linked with neuroticism (Kuppens et al., 2007), but it is also distinct. Neuroticism in tandem with other personality factors and mean affect has been shown to explain up to 52% of variance in affect variability, which is considered

a distinct between-person trait (Eid & Diener, 1999). Notably, gender has not emerged as an individual difference measure correlated with affect variability; men and women display similar positive and negative affect variability (Ferrer et al., 2012). However, age has been identified as a key individual difference, with older adults generally showing less pronounced affect variability compared to younger adults (Brose et al., 2013; Röcke & Brose, 2013). This dissertation focuses on community-dwelling older adult samples, but an understanding of individual differences in affect variability in clinical and non-clinical populations helps contextualize the construct.

The current literature on affect variability and health is largely based on cross-sectional findings (Ong & Ram, 2017), and there are calls for an integration of multiple timescales (Ram et al., 2014). Repeated daily life assessments over multiple days are well-suited for examining short-term fluctuations in affect. Longitudinal follow-ups that track disease risk markers and health conditions over longer time periods are uniquely suited to help us better understand how such everyday affect variability processes accumulate over time. This dissertation aimed to examine proximal pathways (e.g. cortisol) that can speak to how fluctuations in emotional experiences ‘get under the skin,’ while also linking affect variability to cumulative wear-and-tear and distal changes in health. To do so, momentary changes in biomarkers, such as salivary cortisol, may be a way to understand relations between affect variability and proximal indicators of health (e.g. Daly et al., 2014; Human et al., 2015). Longitudinal changes in physiological measures, such as cardiovascular risk indices, can be reflective of distal health outcomes that are assumed to change over years (e.g. Chan et al., 2016; Wang et al., 2012).

1.3 A Social-Contextual Approach to Emotional Experiences in Older Age

Much of the literature on emotional experiences and health has focused on cross-sectional observations from samples of unrelated individuals. However, there is an increasing recognition that emotional experiences are not experienced in a social vacuum (Butler, 2015; DeLongis & Morstead, 2019; Hoppmann & Gerstorf, 2016; Stanley & Isaacowitz, 2014). Affective processes do not only unfold while we are alone, and how we respond to different situations can depend on our relationships with important social others. For example, in a sample of caregivers to relatives living with Alzheimer's disease, age-related increases in heart-rate reactivity to lab-based stressors were only observed in participants with low social support, while participants with high social support showed more typical age-related decreases in heart-rate reactivity (Uchino et al., 1992). In many cases, the spouse especially may act as a first line of defense for coping with situations that elicit negative emotional experiences (Berg & Upchurch, 2007; Stephenson et al., 2014). Further, emotional experiences are often related within couples as they age together. For example, partners are likely to experience similar levels of and changes in happiness over several decades, relative to unrelated pairs of individuals (Hoppmann et al., 2011).

Importantly, socially interconnected emotional experiences may also correspond with physical and psychological vulnerabilities in old age. For instance, older adult couples have been found to show greater cardiovascular reactivity and higher blood pressure responses to collaborative problem-solving compared to middle-aged adults (Smith et al., 2009). Hence, 'linked lives' can represent a double-edged sword, with resources such as collaborative coping benefiting daily mood (Berg et al., 2008), but also introducing potential vulnerabilities like greater propensity to share in the negative affect of one's partner from moment to moment (Berg et al., 2011; Yorgason et al., 2012).

1.4 Dyadic Gain-Loss Dynamics Across the Adult Lifespan

High quality marriages have long been established as protective to health, with married individuals overall enjoying better physical and mental health than unmarried or divorced individuals (Johnson et al., 2000; Robles & Kiecolt-Glaser, 2003). However, being in a strained marriage has been associated with worse health outcomes compared to being single or divorced (Hawkins & Booth, 2005; Holt-Lunstad et al., 2008; Umberson et al., 2006). In other words, associations of marriage with physical and mental health do not seem to be ubiquitously beneficial, but depend upon relationship dynamics. Indeed, dyadic longitudinal data suggest that increases in positive marital quality are associated with increases in self-rated health over a 4 year period in middle-aged and older adults (Choi et al., 2016). Extant research suggests that long-term married older adults have particularly positive relationships (Fingerman & Charles, 2010; Story et al., 2007). For example, while discussing a marital problem in the lab, older adult couples express less negative affect, more affection, and less physiological arousal (controlling for differences in affect), compared to their middle-aged counterparts (Carstensen et al., 1995; Levenson et al., 1994). Of note, while marriage generally seems to be a protective factor in older age, close interdependencies may also introduce potential vulnerabilities.

A number of theoretical frameworks in the stress, coping, and lifespan developmental literatures offer conceptual insights into spousal health linkages (Berg & Upchurch, 2007; M. M. Baltes & Carstensen, 1999; Hoppmann & Gerstorf, 2016; Preece & DeLongis, 2005). Inherent to all is a recognition that partners have the potential to share their resources and engage in strategies that help each other to accomplish what would not be possible alone, but also that they have the potential to bring each other down (Schoebi, 2008; Umberson et al., 2010; Weldon & Bellinger, 1997). Such gain-loss dynamics can take intricate forms if what is beneficial for one

partner ends up hurting the other partner or the couple as a whole (M. M. Baltes & Carstensen, 1999).

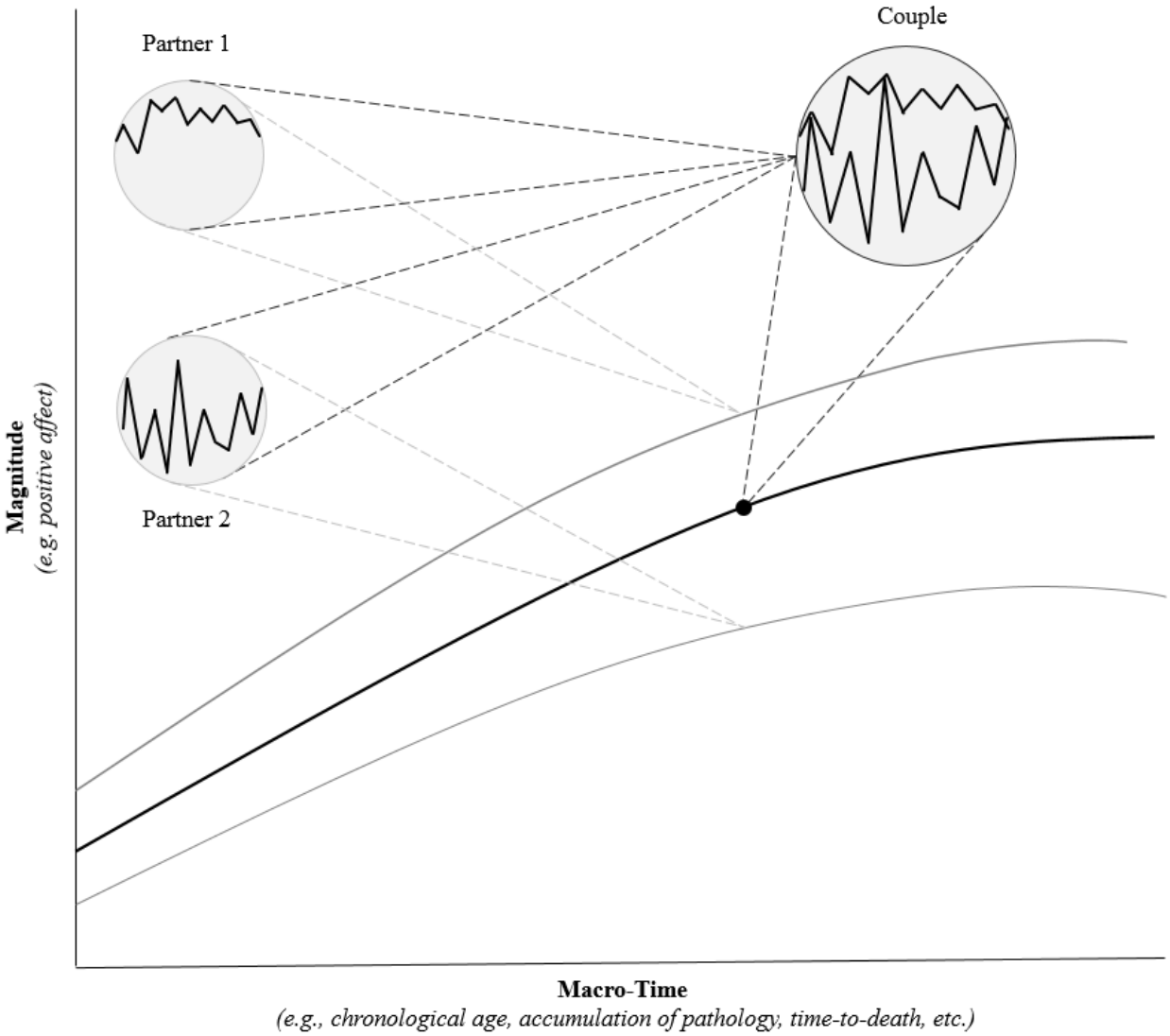


Figure 1.1 Conceptual framework underlying research program

The conceptual framework underlying this dissertation proposes that fluctuating emotional experiences shape individual and spousal health trajectories, which are interrelated within a gain-loss dynamic (*Figure 1.1*; Michalowski et al., 2018). Each partner has their own everyday fluctuations that are part of a daily couple dynamic, which in turn shapes the

interrelated trajectory of the couple (black lines). Each unique partner also has their own unique trajectory beyond the couple (light grey lines). The solid lines depict individual and couple macro-time changes, while the dotted lines connect the zoomed-in micro-time 'bubbles' to their respective points on the macro-time lines. Individual trajectories shape the direction of the couple trajectory, which in turn either brings the individual up or down through time.

Further, this model assumes that short-term processes accumulate into long-term trajectories: short-term fluctuations may reflect flexible responding to changing daily life situations, which is adaptive, but repeated and prolonged activation of stress responses, for example, can accumulate into wear-and-tear (G. E. Miller et al., 2007; Piazza et al., 2018). Importantly, age-related wear-and-tear on physiological systems may mean that older adults are especially vulnerable to break downs in emotion regulation strategies. Hence, investigations of emotional experiences and health in aging couples require a close consideration of proximal correlates and distal consequences. The studies included in this dissertation are each geared towards examining select aspects of this broader conceptual framework, with a specific focus on short-term changes in emotional experiences in daily life, corresponding links with relationship processes (i.e. empathic accuracy; Chapter 2), proximal health indices (i.e. salivary cortisol fluctuations; Chapter 3), and distal health (i.e. annual changes in cardiovascular risk and environmental mastery; Chapter 4).

1.5 Chapter 2: Intraindividual Variability and Empathic Accuracy for Happiness in Older Couples

In order to better understand how affect dynamics impact the everyday lives of couples, one natural first step may be to consider the role of affect variability in the perception of emotional experiences between partners, or 'empathic accuracy.' Empathic accuracy (Ickes,

1993) is defined as the degree to which one is able to accurately detect the ever-changing thoughts and feelings of another individual, and in this dissertation specifically, the happiness of one's spouse. While empathic accuracy has traditionally been studied as an inter-individual trait, it also varies from one situation to the next (Blanke & Riediger, 2019; Rauers et al., 2013). To capture the time-varying nature of empathic accuracy, it is operationalized as 'pattern accuracy' (Howland & Rafaeli, 2010; Hülür et al., 2016), which reflects fluctuations in empathic accuracy over repeated daily life assessments.

Empathic accuracy is inherently a dyadic process, by which a target (the person whose emotions are being inferred) must make relevant cues available to the perceiver (the person inferring the emotions of another person), who must in turn be able to detect and interpret these cues (Funder, 1995). Hence, both perceiver and target affect variability may matter for empathic accuracy. Previous research on empathic accuracy of therapists for their clients suggests that clients (i.e. targets) who fluctuate less in their positive and negative affect are more accurately understood by their therapist (i.e. perceiver; Lazarus et al., 2019), which dovetails with findings from the personality literature suggesting that individuals with more stable personality traits are also more accurately read (Biesanz & West, 2000). On the other hand, younger adults who fluctuate more in their negative affect tend to over-estimate their partner's quarrelsome behaviour following naturalistic conflict interactions (Sadikaj et al., 2015).

I specifically focused on accuracy for happiness based on evidence from the aging literature that, compared to younger and middle-aged adults, older adults tend to experience more variability in positive affect relative to negative affect (Röcke et al., 2009). Older adults also tend to selectively allocate limited cognitive resources to emotionally meaningful

experiences, such as positive experiences within partnership (Mather & Carstensen, 2005; Story et al., 2007; see Reed et al., 2014 for a meta-analysis).

Taken together, Chapter 2 investigates concurrent associations between short-term fluctuations in emotional experiences and empathic accuracy, a key relationship process for understanding the emotional experiences of one's partner. Specifically, I examined associations between variability in and empathic accuracy for happiness in the everyday lives of older adult couples. I hypothesized that partners with greater happiness variability would be 1) harder to read in terms of their own happiness, but 2) able to more easily read their spouse's happiness. Considering that cues must be made available and perceived by one's partner for empathic accuracy to occur (Funder, 1995), I also explored time-varying perceptions of the degree to which one perceives their partner to be sharing their feelings as a moderator of these associations. Given recent concerns regarding the replicability of psychological research (Open Science Collaboration, 2012, 2015), I examined my hypotheses in two samples of older adult couples, using a coordinated analysis approach (Hofer & Piccinin, 2009; Weston et al., 2020), where parallel statistical protocols are used across different data sets. A better understanding of how fluctuations in emotional experiences might 'get under the skin' requires linkages with corresponding time-varying biomarkers, such as salivary cortisol. This was the primary goal of Chapter 3.

1.6 Chapter 3: Time-Varying Associations Between Everyday Sadness, Contentment, and Cortisol are Moderated by Sharing Feelings in Older Adult Couples

Cortisol secretion is a biologically plausible pathway by which emotional experiences 'get under the skin' to shape longer-term health trajectories. The goal of Chapter 3 was to

investigate concurrent associations between time-varying salivary cortisol and not only one's own fluctuating emotional experiences, but also those of one's partner. Cortisol is uniquely suited to examine the connection between emotional experiences and health, because it reflects Hypothalamus-Pituitary-Adrenal (HPA) activation, a key stress response system, and it has well-established associations with physical and mental health (Piazza et al., 2010; Seeman & Gruenewald, 2006). Most previous research linking emotional experiences with cortisol has focused on broad positive and negative affect composites. Generally, positive affect is protective and linked with lower concurrent cortisol levels (Nater et al., 2010; Smyth et al., 1998; Steptoe & Wardle, 2005; Steptoe et al., 2007; Steptoe et al., 2005), while negative affect is detrimental and associated with higher corresponding cortisol levels (Adam et al., 2006; Smyth et al., 1998), although affect-cortisol associations are not always consistent (e.g. Polk et al., 2005).

This dissertation specifically focused on two prominent emotional experiences in old age that may show unique links with cortisol levels. Laboratory studies with lifespan samples have shown that older adults experience equivalent or higher levels of sadness, relative to younger adults (Kunzmann & Gruhn, 2005; Kunzmann et al., 2013; Kunzmann et al., 2017; Seider et al., 2011). Sadness may become especially prominent in older age, because it facilitates disengagement from goals that are no longer attainable due to age-related resource loss (Haase et al., 2013; Wrosch & Heckhausen, 1999).While sadness has been given a lot of attention in the aging literature, there is a growing recognition for the role of positive emotions for health (Cohen & Pressman, 2006; Fredrickson, 2001; Steptoe et al., 2005). Contentment specifically facilitates one's ability to savour life as it is and ultimately build personal resources for coping with challenges (Fredrickson, 2001). Hence, Chapter 3 considers sadness and contentment as

especially salient discrete, health-relevant emotional experiences in the everyday lives of older adults.

In line with the general scope of this dissertation, Chapter 3 extends affect-cortisol linkages beyond the individual to account for the marital context. The existing literature suggests that emotional experiences are often transmitted and co-vary between spouses (Hoppmann et al., 2011; Larson & Almeida, 1999; Michalowski et al., 2018), and couples often show cortisol linkage or synchrony (Pauly et al., in press; Saxbe et al., 2019; Timmons et al., 2015). Few studies have extended affect-cortisol linkages to the marital dyad, which is limiting, given interrelations between spouses. Initial evidence from younger couples with small children has shown that higher trait marital disclosure (the extent to which one shares their thoughts and feelings with their spouse) buffers momentary associations between work worries and cortisol levels (Slatcher et al., 2011). In this study, wives showed cortisol responses to not only their own work worries, but also to their spouse's work worries, whereas husbands did not. High marital disclosure dampened associations between their own work worries and cortisol. Given changed relationship dynamics in long-term marriages post-retirement, it is unclear whether gender differences emerge to the same degree in older adult couples. In line with this evidence, I took into consideration whether disclosing one's emotions to one's spouse in older age may be beneficial (i.e. representing a social resource).

Taken together, Chapter 3 aimed to examine dyadic affect-cortisol linkages, with a focus on sadness and contentment as especially relevant emotional experiences in the everyday lives of older adult couples. I hypothesized that within-person increases in sadness would be associated with concurrent increases in cortisol, while within-person increases in contentment would be

associated with concurrent decreases in cortisol. I also hypothesized that if partners were perceived to be sharing their feelings, then their sadness would be associated with increased cortisol and their contentment would be associated with decreased cortisol levels. Hence, Chapter 3 delves into dyadic gain-loss dynamics, by recognizing the spouse as a key social resource, while also recognizing potential vulnerabilities that come with interrelated emotional experiences in marital relationships.

To understand how short-term fluctuations in emotional experiences and health indices like cortisol may accumulate into longer-term physical and mental health outcomes, long-term longitudinal data are needed. Chapter 4 combines short-term affect variability with long-term physical and mental health indices to do just that.

1.7 Chapter 4: Dyadic Associations Between Everyday Affect Variability and Levels of and Subsequent Changes in Cardiovascular Risk and Environmental Mastery

Chapters 2 and 3 focused on proximal correlates of emotional experiences in older adult couples. A primary aim of the fourth chapter was to extend the existing body of research by recognizing that dynamic links between spousal emotional experiences are present in both everyday contexts, but also across longer periods of time (Berg et al., 2011; Hoppmann et al., 2011; Hicks & Diamond, 2008; Larson & Almeida, 1999; Michalowski et al., 2018; Monin & Schulz, 2009). Thus, Chapter 4 widens the lens of focus to explore how short-term fluctuations in emotional experiences can accumulate and shape physical and mental health outcomes that take longer periods of time to develop (months, years). Longitudinal assessments in combination with repeated daily life assessments are ideal for testing such expectations. I am not aware of previous research linking affect variability with subsequent long-term changes in physical and

mental health. Previous longitudinal evidence suggests that affective reactivity to daily stressors is linked to increases in chronic health conditions (Piazza et al., 2013) as well as general affective distress a decade later (Charles et al., 2013). Extending these findings to affect variability, I assumed that the repeated activation of physiological stress systems targeted in Chapter 3 may accumulate over time.

Specifically, I focused on longer-term changes in an objective indicator of physical health (cardiovascular risk) as well as a subjective indicator of mental health (environmental mastery), both of which are especially pertinent in older age. Cardiovascular risk was operationalized as pulse pressure, which is prone to age-related increases and reflects greater artery calcification and coronary heart disease risk (Franklin et al., 1997). Environmental mastery was operationalized as the match between one's needs and capabilities and the demands of one's environment (Ryff, 1989, 2008). Previous cross-sectional research has demonstrated that high positive and negative affect variability are linked with a variety of cardiovascular risk indicators (Jones et al., 2020; Koval et al., 2013), and that higher mastery is associated with lower physiological reactivity to work stressors and lower emotional reactivity to network stressors (Neupert et al., 2007). I therefore expected that greater positive and negative affect variability, whether one's own or one's spouse's, would be linked with greater initial levels of and increases in pulse pressure, but lower initial levels of and decreases in environmental mastery, over three years. Similar to Chapters 2 and 3, I expected that sharing emotions in long-term marital relationships would be related to better health over time (Driver & Gottman, 2004; Haase et al., 2016).

1.8 Study Overview

Data from the Linked Lives project was core to examining each of the research questions outlined above. The broader project was designed to target spousal health dynamics in community-dwelling older adult couples residing in the Greater Vancouver Area. Study procedures involved in-person interview sessions, and repeated daily life assessments (four assessments over 7 days, for up to 28 assessments per individual). Annual follow-up assessments involved in-person interview sessions, but they did not include the daily life assessment module. Participants were able to return annually even if their spouse did not. From the overall number of participants who entered the study (*n* = 258 individuals), 18 participants did not complete the repeated daily life assessment phase after already completing the initial in-person interview session. An additional couple (*n* = 2 individuals) was excluded from all data analyses presented in this dissertation due to language difficulties, resulting in a sample size of 238 participants (or *n* = 119 couples).

From this base sample, an additional 2 couples (*n* = 4 individuals) were excluded in the analyses for Chapter 2, because one or both spouses only reported extreme happiness ratings, resulting in a final subsample of 117 couples (*n* = 234 individuals). Repeated daily life assessments were excluded if any assessment points were not completed by both partners, due to the dyadic focus on the analyses (*n* = 446 out of 6552 possible assessments), resulting in a total of 6106 observations. A sister data set, the Berlin Couple Dynamics project, that also examined community-dwelling older adult couples was used in Chapter 2 to address replicability of findings. From an initial sample of 110 couples, data were excluded if one or both spouses had missing data (*n* = 2 couples) or did not complete the repeated daily life assessments (*n* = 1 couple), resulting in a final subsample of 107 couples. Procedures in the Berlin study also

involved repeated daily life assessments, but on a different schedule (6 times per day over 7 days for up to 42 assessments per individual). As with the Linked Lives data, repeated daily life assessments were excluded if not completed by both spouses (*n* = 146 out of 8988 possible assessments), resulting in a total of 8842 observations.

For Chapter 3, any couples where one or both spouses had conditions that would render cortisol values uninterpretable, were not asked to provide saliva samples (*n* = 28 couples). Additional couples who did provide salivary samples were excluded due to out of range cortisol values that were linked to identified health conditions (*n* = 4 couples), missing cortisol data (*n* = 2 couples), or because either partner was missing information about waking time (a key covariate) on all repeated daily life assessment points (*n* = 1 couple). Hence, the subsample retained for Chapter 3 included data from 84 couples. Repeated daily life assessments were excluded if missing data from either partner, due to the dyadic focus on the analyses (*n* = 572 out of 4704 possible assessments), resulting in a total of 4132 observations.

A unique feature of the Linked Lives project is that it included annual follow-up assessments (Chapter 4). Of the 238 participants (or 119 couples) included in Year 1, 178 participants returned in Year 2, and 174 participants returned in Year 3, resulting in an approximately 75% retention rate for the longitudinal component of the study. Participants were able to return in Year 3, even if they did not return in Year 2. Only 40 participants did not complete either of the annual follow-up assessments, and so 198 participants did complete at least one follow-up. The subsample retained for analyses in Chapter 4 included the 119 couples in Year 1, with full information maximum likelihood used to estimate missing data from following years.

Across all studies, the number of repeated daily life assessments (28 to 42) and retained number of couples (84 to 119) was in line with sample size recommendations for achieving adequate power in multilevel analyses (Maas & Hox, 2005; Scherbaum & Ferreter, 2009).

Chapter 2: Intraindividual Variability and Empathic Accuracy for Happiness in Older Couples

2.1 Introduction

Older spouses are often each other's first line of defense (Berg & Upchurch, 2007). To provide effective support, one must be able to accurately understand others' emotional experiences (Human & Biesanz, 2013). To date, most research on empathic accuracy has focused on accurately detecting emotional experiences using younger adult samples and laboratory paradigms (Gagné & Lydon, 2004; Fletcher & Kerr, 2010; refer to Hülür et al., 2016; Rauers et al., 2013; Wilhelm & Perrez, 2004 for exceptions). This is limiting as seminal work on developmental changes in emotional experiences suggests that older adults prioritize meaningful social relationships and positive emotional experiences (Carstensen et al., 2003; Mather & Carstensen, 2005); understanding and regulating positive emotional experiences in significant relationships is particularly important in old age. The current chapter tackled this gap by studying empathic accuracy for happiness among older partners and linking this to emotional experiences (i.e. happiness variability). Because emotional experiences are dynamic and vary across daily life situations (Röcke & Brose, 2013), repeated daily life assessments were used to examine how fluctuations in happiness may be intertwined with everyday empathic accuracy.

2.1.1 Empathic Accuracy

Empathic accuracy (Ickes, 1993) is defined as the extent to which someone is able to accurately detect the transitory thoughts and feelings of another person. Empathic accuracy is often viewed as a trait (e.g. the ability to accurately detect other peoples' feelings). However, it may also vary from one situation to the next, with the same individual being more or less

accurate depending on time-varying situational circumstances. Empathic accuracy is guided by motivational processes in the service of emotion and relationship regulation that change over time (Blanke & Riediger, 2019). This emphasizes the need to consider person- and couple-specific as well as situational characteristics to better understand the mechanisms underlying empathic accuracy.

Empathic accuracy requires a target (the person whose emotions are being inferred) to make relevant cues available to the perceiver (the person inferring the emotions of another person), and the perceiver to detect and interpret these cues (Funder, 1995). Laboratory-based research has shown that older adults are worse targets and less accurate perceivers, compared to younger adults (Ruffman et al., 2019). However, older adults can capitalize on their experience with their partner in everyday life: older adults show similar levels of empathic accuracy independent of whether their partner is present – unlike younger adults who are less accurate when their partner is absent versus present (Rauers et al., 2013). Such findings are consistent with the idea that older adults selectively allocate their cognitive resources to personally relevant tasks (Hess, 2014; Issacowitz et al., 2016) and that they are particularly motivated to attend to emotionally meaningful experiences, including positive experiences within their partnership (Story et al, 2007; Mather & Carstensen, 2005; see Reed et al., 2014 for a meta-analysis). The present study expanded on this evidence by examining empathic accuracy for positive emotional states (e.g. happiness), and used repeated daily life assessments obtained as older couples engaged in their everyday lives (Hoppmann & Riediger, 2009). Following Howland and Rafaeli (2010) and Hülür et al. (2016), empathic accuracy was operationally defined as ‘pattern accuracy,’ which captures changes in empathic accuracy for happiness across time.

2.1.2 Intra-Individual Affect Variability

In everyday life, positive emotional experiences such as happiness fluctuate as individuals move from one situation to the next. Positive affect variability captures the degree to which positive affect fluctuates within a given individual across different situations (Ong & Ram, 2017). There are multiple ways of operationally defining intra-individual affect variability (Ebner-Priemer et al., 2007; Ram & Gerstorf, 2009). The intra-individual standard deviation (iSD; Ram & Gerstorf, 2009) is the most widely used index of intraindividual variability, due to its simple calculation and intuitive interpretation (e.g. a higher iSD reflects a greater amplitude of change across measurement points).

Positive affect variability matters for how well an individual is understood by others (Hülür et al., 2016). For example, Lazarus et al. (2019) found that therapists more accurately read the positive and negative affect of clients who fluctuate less in their affect, relative to clients who fluctuate more. These findings suggest that targets who fluctuate less in their affect may be more accurately understood by perceivers. This dovetails with the personality literature, which suggests that individuals whose personality traits are more stable are more accurately read (Biesanz & West, 2000). Hence, partners who fluctuate less in their affect may be more easily read than partners who fluctuate more.

To date, little research has addressed the role of perceiver happiness variability for empathic accuracy. Sadikaj et al. (2015) showed that younger adults with greater negative affect variability over-estimated their partner's quarrelsome behavior following a conflict interaction in daily life, suggesting that greater perceiver fluctuations in negative affect are associated with less accurate perceptions of target behaviors. Recognizing conceptual overlap between affect variability and neuroticism (i.e. emotional instability as a characteristic of neuroticism; Eid &

Diener, 1999), I also drew on findings indicating that partners high in neuroticism show increased vigilance to their spouse's everyday problems (Lay & Hoppmann, 2014). Hence, partners high in affect variability may be particularly vigilant to the emotional states of others and show greater empathic accuracy, relative to those lower in affect variability. I also drew on another area in the emotion dynamic literature, namely emotion differentiation. For example, individuals who are better at differentiating their own emotions are more empathically accurate at inferring the positive emotional experiences of others (Erbas et al., 2016). Although identifying different discrete emotions (i.e. emotion differentiation) differs conceptually from reporting varying levels of emotional intensity (i.e. affect variability), both represent the idea that paying close attention to emotional states can help detect how others are feeling. Hence, greater affect variability among perceivers may be positively related to accurately reading the emotional experiences (i.e. happiness) of others.

Considering that older adults are motivated to focus on positive socio-emotional experiences (Carstensen et al., 2003), my aim was to extend this literature to older couples. I focused on positive emotional experiences, which are particularly salient in older age. Hülür et al. (2016) examined happiness variability in relation to three measures of empathic accuracy (level, scatter, & pattern accuracy; Howland & Rafaeli, 2010) in a sample of older couples. They found that perceivers tended to be less accurate and underestimated their partner's happiness levels (level accuracy) and happiness variability (scatter accuracy) when their partner had greater happiness variability. They did not find that having a partner high in happiness variability moderated momentary empathic accuracy (pattern accuracy), although it is important to note that this was not the main focus of their study.

2.1.3 The Current Study

This study built on and extended previous research by examining happiness variability as a moderator of pattern accuracy for happiness in older couples. I differentiated between perceiver and target happiness variability in recognition of the interpersonal nature of empathic accuracy — both the target and the perceiver are involved in what is ultimately a dyadic process. I expected that target happiness variability is negatively associated with pattern accuracy for happiness: if one's partner is more stable in happiness, then highs and lows should be easier to detect, because they stand out relative to the highs and lows of partners who fluctuate a lot. I also expected that partners high in happiness variability are more attentive to emotional cues, so high perceiver happiness variability should amplify pattern accuracy for happiness.

To provide a meaningful interpretation of the predicted associations, I took into account situational-, person-, and couple-specific characteristics that may influence empathic accuracy including gender (Fujita et al., 1991), age (Gross et al., 1997), relationship satisfaction and duration (Ickes & Simpson, 1997), partner presence (Rauers et al., 2013; Wilhelm & Perrez, 2004), and mean happiness (Devlin et al., 2014). I further explored the time-varying role of partners sharing their emotions on the predicted associations. Given replicability concerns in psychological research (Open Science Collaboration, 2012, 2015), I used coordinated analysis (Hofer & Piccinin, 2009) across two data sets.

2.2 Methods

2.2.1 Participants and Procedures

Two separate samples (Berlin, Germany; see Brinberg et al., 2017; Drewelies et al., 2018; Hülür et al., 2016; Vancouver, Canada; see Ashe et al., 2019; Pauly, Keller, et al., 2019; Pauly, Michalowski, et al., 2019) of cohabitating community-dwelling couples were recruited to

provide repeated daily life assessments. The Vancouver study involved annual follow-ups, but only Year 1 data were used (the only year that participants provided repeated daily life assessments). Participants were recruited through community advertisements and subject pools. A total of 110 couples participated in Berlin and 129 in Vancouver.

The final Berlin sample included 107 German-speaking couples (*M* age = 75.2 years, *SD* = 3.82, range = 67 – 93; no ethnic information available; *M* self-rated health = 2.37, *SD* = 0.70, 1 = "very good" to 5 = "very poor"; *M* years of education = 14.1, *SD* = 3.03, range = 8 – 18). Couples were excluded if either spouse had missing data (*n* = 2) or did not complete any of the repeated daily life assessments (*n* = 1)[1]. Days in study were rated as typical of everyday life (*M* = 3.65, *SD* = 1.10; 1 = "not at all" to 5 = "very much").

The final Vancouver sample included 117 couples (*M* age = 71.1 years, *SD* = 5.99, range = 60 – 87; 60% Caucasian, 34% East Asian, 6% Other; *M* self-rated health = 3.27, *SD* = .95, 1 = "poor" to 5 = "excellent"; 66% with some college). Couples were excluded if either spouse did not complete (*n* = 9) or only reported extreme ceiling happiness ratings in their (*n* = 2) daily life assessments, or had language difficulties (*n* = 1). To be inclusive of local demographics, participation was offered in English, Mandarin, and Cantonese; 33 couples completed the study in Mandarin, the rest in English. Spouses completed the study in the same language. Participants rated days in study as typical of their everyday lives (*M* = 3.77, *SD* = 1.05; 1 = "not at all" to 5 = "very much").

[1] An additional 4 couples dropped out in Berlin before completing daily life assessments, but are not counted in the final sample.

The Berlin study schedule included 6 assessments of the targeted variables per day (at waking, 10:00, 13:00, 16:00, 19:00, 21:00), over 7 days (42 assessments/individual). The Vancouver study included 4 assessments (at waking, 11:00, 16:00, 21:00), over 7 days (28 assessments/individual). Participants showed excellent protocol adherence (Berlin: 99.1%; Vancouver: 96.9%). Partners answered questions simultaneously, but independently, on separate devices. Partners were instructed to not share their responses with each other until after the study was over. Any assessment points not completed by both partners were excluded (Berlin: n = 146 of 8988 possible assessments; Vancouver: n = 446 of 6552 possible assessments), due to the dyadic focus of the analyses.

Electronic daily life assessments were completed using the iPad-based iDialogPad application (G. Mutz, Cologne, Germany). The application was programmed to 'beep' at each assessment point, and participants were instructed to complete each assessment within the 30-minutes before or after that beep (provided it was safe to do so); the waking assessment was self-elicited before 10:00 (Berlin) and 11:00 (Vancouver). Participants in Berlin were allowed to adjust their assessment times if it conflicted with preexisting commitments. Of all device-elicited assessments (Vancouver: 11:00, 16:00, and 21:00; 4536 responses in total; Berlin: 13:00, 16:00, 19:00, and 21:00; 7,530 responses in total), percentage completed within 30 minutes of the beep was 88.3% (Vancouver) and 68.4% (Berlin); 94.7% (Vancouver) and 79.6% (Berlin) within an hour; and 97.1% (Vancouver) and 92.9% (Berlin) within 90 minutes.

Participants provided informed written consent. Each partner was reimbursed 100€ plus a small gift (Berlin), and $100 CAD (Vancouver). Ethics approval was granted separately for each study from the Humboldt University Department of Psychology Ethics Committee and the University of British Columbia Clinical Research Ethics and Behavioral Research Ethics Boards.

2.2.2 Measures

2.2.2.1 Momentary Self-Reported Happiness

Happiness was assessed using a slider-bar from 0 ("not at all") to 100 ("very much"). On average, participants rated their current happiness as 67.0 (*SD* = 15.4, range = 5.02 - 98.5; Berlin), and 74.2 (*SD* = 13.3, range = 19.00 – 99.96; Vancouver).

2.2.2.2 Momentary Perceived Happiness

Partner happiness was assessed using the same 0-100 slider-bar. Participants rated their partner's happiness without directly asking their partner. On average, participants rated their partner's happiness as 65.1 (*SD* = 15.3, range = 6.24 – 98.0; Berlin), and 69.8 (*SD* = 13.8, range = 25.5 – 99.3; Vancouver).

2.2.2.3 Intraindividual Happiness Variability (iSD)

Mean happiness iSD was 15.5 (*SD* = 6.39, range = 3.94 – 37.1; Berlin), and 12.8 (*SD* = 5.96, range = .20 – 31.6; Vancouver). Split-half reliability was .67 (Berlin) and .61 (Vancouver; split-half reliability for intraindividual mean happiness in both studies was .91).

2.2.2.4 Covariates

In the Berlin study, participants were first asked if they were alone, and if not, a branched question asked who they were with. If alone, it was assumed their partner was not present. In Vancouver, this information was combined into one item. Partner presence was dichotomous in both studies (0 = "partner not present", 1 = "partner present"). Overall, partners were present at 75.6% (*SD* = 23.9%, range = 0% - 100%; Berlin) and 77.8% (*SD* = 18.3%, range = 16.7% - 100%; Vancouver) of assessment points.

On average, couples were married for 45.8 years (*SD* = 12.1, range = 2 – 64; Berlin), and 41.1 years (*SD* = 13.0, range = .5 - 64.0; Vancouver). Relationship satisfaction was measured

with the single item “All in all, how would you rate your current relationship?” (*M* = 4.54, *SD* = .56, range = 3 – 5; 5-point scale from 1 = “very bad” to 5 = “very good”; Berlin) and the Relationship Satisfaction Questionnaire (Hendrick, 1988; *M* = 4.17, *SD* = .70, range = 2 - 5; 5-point scale from 1 = “not at all” to 5 = “very much”; alpha = .89; Vancouver). Demographic variables included gender (0 = man, 1 = woman; 50% men, 50% women in Vancouver; 49.5% men, 50.5% women in Berlin), age, and language of study administration (0 = Mandarin, 1 = English; Vancouver only).

As part of exploratory follow-up analyses, I examined the extent to which one’s partner was sharing their feelings (0 = “not at all” to 100 = “very much”, 100-pt slider-bar; Berlin: *M* = 63.05, *SD* = 26.48, range = 0-100; Vancouver: *M* = 52.32, *SD* = 31.17, range = 0-100).

2.2.3 Analytic Strategy

I integrated the Actor Partner Interdependence Model (APIM; Kenny et al., 2006) with the Truth and Bias Model (West & Kenny, 2011; *Figure 2.1*).

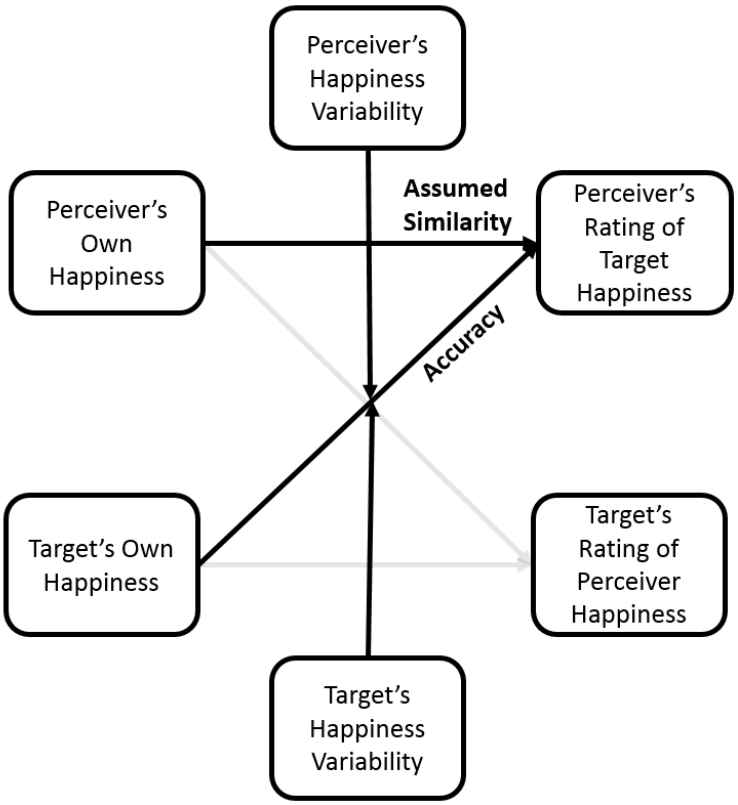


Figure 2.1 Actor Partner Interdependence Model integrated with the Truth and Bias Model.

The APIM takes both 'actor' (one's own perspective) and 'partner' (one's partner's perspective) reports into account. The Truth and Bias Model also accounts for these dyadic perceptions, but coins them 'perceiver' and 'target'. This approach has been fruitfully applied to daily life assessments (e.g. Rauers et al., 2013; Sadikaj et al., 2015). In the Truth and Bias Model, 'tracking accuracy' (i.e. 'truth force') is the strength of association between the perceiver's rating of the target's happiness and the target's rating of their own happiness; 'assumed similarity' (i.e. 'bias force') is the strength of association between the perceiver's rating of target happiness and the perceiver's rating of their own happiness.

I specifically focused on 'pattern accuracy' (Howland & Rafaeli, 2010; see Hülür et al., 2016), which indexes empathic accuracy for changes in happiness, and is conceptually similar to

tracking accuracy. The dependent variable is momentary perceiver ratings of target happiness, and the independent variable is momentary target ratings of one's own happiness; the slope between the two represents pattern accuracy (i.e. a steeper slope indicates higher accuracy).

Multilevel modelling was used to account for the nested data structure. Power is complex in multilevel analyses, but generally, simulations show that standard errors tend to be adequately estimated with more than 50 clusters (i.e. couples in the current research; Maas & Hox, 2005). Three levels were modelled, with repeated daily life assessments or 'moments' nested within individuals, nested within couples. Proportions of variation in the outcome variable (perceiver's rating of target happiness) were modelled with unconditional models, and indicated that 51.4% of variance was at the momentary level, 20.5% at the individual level, and 28.1% at the couple level (Berlin); in the Vancouver sample, 55.4% of variance was at the momentary level, 24.5% at the individual level, and 20.1% at the couple level.

Associations between perceiver ratings of target happiness and target's rating of own happiness (i.e. pattern accuracy slopes), as well as time-varying covariates, such as partner presence and perceiver ratings of own happiness (i.e. assumed similarity), were examined through the following model (*Model C*) at Level 1:

Perceiver rating of target happiness $s_{\mathrm{ijk}} = \beta_{0\mathrm{jk}} + \beta_1$ (partner presence) $+ \beta_{2\mathrm{jk}}$ (perceiver rating of own happiness) $+ \beta_{3\mathrm{jk}}$ (target rating of own happiness) $+ r_{\mathrm{ijk}}$

where perceiver rating of target happiness s_{ijk} reflects perceiver j's rating of target happiness within couple k at assessment point i, as a function of a time-varying intercept $\beta_{0\mathrm{jk}}$ and time-varying coefficients. β_1 represents whether perceiver ratings of target happiness differ when the

target is present. β_{2jk} represents whether perceiver ratings of their own happiness corresponds with their ratings of target happiness (i.e. assumed similarity or bias). β_{3jk} represents whether target ratings of their own happiness corresponds with perceiver ratings of target happiness (i.e. pattern accuracy). r_{ijk} represents residual error variance that is auto-correlated (AR1) across repeated daily life assessment points. Cross-level interactions between target's rating of own happiness and target happiness iSD as well as perceiver happiness iSD indexed the moderating role of target and perceiver happiness iSD for the pattern accuracy slopes.

Perceiver age, target age, gender, perceiver relationship satisfaction, target relationship satisfaction, perceiver happiness iSD, target happiness iSD, perceiver mean happiness, and target mean happiness were added as individual-level covariates, resulting in the following Level 2 model:

$\beta_{0jk} = \gamma_{00k} + \gamma_{01}$ (perceiver age) + γ_{02} (target age) + γ_{03} (gender) + γ_{04} (perceiver relationship satisfaction) + γ_{05} (target relationship satisfaction) + γ_{06} (perceiver happiness iSD) + γ_{07} (target happiness iSD) + γ_{08} (perceiver mean happiness) + γ_{09} (target mean happiness) + u_{0j}

$\beta_{2jk} = \gamma_{20k} + u_{2j}$ $\beta_{3jk} = \gamma_{30k} + \gamma_{31}$ (target happiness iSD) + γ_{32} (perceiver happiness iSD) + u_{3j}

where γ parameters represent whether β parameters, for the typical individual, are associated with older perceiver and target age, being a woman, higher perceiver and target relationship

satisfaction, higher perceiver and target happiness iSD, as well as higher perceiver and target mean happiness. u_{0j} represents residual variation between individuals.

Marriage duration was added as a couple-level covariate, resulting in the following Level 3 model:

$\gamma_{00k} = \delta_{000} + \delta_{001}$ (marriage duration) + δ_{002} (language of study completion) + v_{00k}

$\gamma_{20k} = \delta_{200} + v_{20k}$ $\gamma_{30k} = \delta_{300} + v_{30k}$

where δ_{001} represents whether being married longer is associated with greater average perceptions of target happiness, for the typical couple. δ_{002} represents whether the couple completed the study in Mandarin (in the Vancouver sample only). v_{00k} represents residual variance between couples. v_{20k} and v_{30k} represent between-couple variance of perceiver's and target's own happiness ratings, respectively.

Following the Truth and Bias analytic framework (West & Kenny, 2011), perceiver's rating of target happiness, perceiver's rating of their own happiness, and target's rating of their own happiness are all 'truth' centered, where mean target rating of own happiness across all individuals and measurement points is subtracted from the raw values of each of these variables, allowing the fixed intercept to reflect 'directional bias' averaged across individuals. Directional bias indexes the direction from the mean that perceiver's judgements are biased towards. A negative coefficient indicates underestimation, while a positive coefficient indicates overestimation. The random intercepts estimate directional bias for person *j* and couple *k*, respectively. Fixed slopes estimate the average truth and bias forces across individuals, while

random slopes reflect the truth and bias forces for person *j* and couple *k*, respectively. Any other momentary predictors were person-centered (except partner presence, where a value of zero indicated that the partner was not present). All individual and couple level predictors were grand mean centered (except gender and language of study completion, where zeros were meaningful). All models were estimated using maximum likelihood in the R package nlme (Pinheiro et al., 2019), with degrees of freedom calculated using the 'inner-outer' rule (Pinheiro & Bates, 2000). Cross-level interactions were probed by calculating simple slopes (Preacher et al., 2006).

2.3 Results

2.3.1 Descriptive Statistics

Means, standard deviations, and intercorrelations of key variables are shown in *Table 2.1*. On average, higher partner happiness was associated with higher own happiness in Berlin (r = .81, p < .001) and Vancouver (r = .76, p < .001). Neither partner nor own happiness were associated with partner presence in either study (Berlin: r = .09, p = .354 partner happiness; r = .03, p = .758 own happiness; Vancouver: r = .18, p = .054 partner happiness; r = .11, p = .242 own happiness). Relationship satisfaction was positively associated with partner's happiness ratings (Berlin: r = .20, p = .038; Vancouver: r = .43, p < .001). Gender was not associated with relationship satisfaction (Vancouver: r = –.16, p = .088; Berlin: r = –.10, p = .303). Spouses with higher happiness variability were more likely to rate their own happiness as lower in both the Berlin (r = –.27, p = .005) and Vancouver (r = –.35, p < .001) samples, and rate their partner's happiness as lower, but only in the Vancouver sample (r = .27, p = .004; Berlin: r = –.16, p = .098). Women were higher in happiness variability only in the Berlin sample (r = .23, p = .018; Vancouver: r = .11, p = .242).

2.3.2 The Role of Intraindividual Happiness Variability in Momentary Empathic Accuracy for Happiness

Models were built in a stepwise fashion (*Tables 2.2* and *2.3*). Reductions in deviance were statistically significant from *Model A* (only control variables) to *Model B* (added main effects; Vancouver: $\chi 2 = 1735.6$, $df = 10$, $p < .001$; Berlin: $\chi 2 = 2656.2$, $df = 10$, $p < .001$), from *Model B* to *C* (added two-way interactions; Vancouver: $\chi 2 = 14.2$, $df = 2$, $p < .001$; Berlin: $\chi 2 = 10.8$, $df = 2$, $p = .005$), and from *Model C* to *Model D* (added three-way interactions; Vancouver: $\chi 2 = 329.0$, $df = 8$, $p < .001$; Berlin: $\chi 2 = 464.4$, $df = 8$, $p < .001$), suggesting that each successive model fit the data better than the last.

Perceiver ratings of target happiness were higher than usual when the target also rated their own happiness as higher than usual; pattern accuracy slopes were positive and statistically significant across samples (Berlin: $b = 0.1669$, $SE = 0.0164$, $p < .001$; Vancouver: $b = 0.1896$, $SE = 0.0227$, $p < .001$; *Tables 2.2 and 2.3, Model C*). Average directional bias (indicated by the fixed effect intercept) was negative and statistically significant, suggesting that perceivers tended to underestimate target happiness (Berlin: $b = –4.6591$, $SE = 0.9504$, $p < .001$; Vancouver: $b = –6.0464$, $SE = 1.4121$, $p < .001$). Perceivers rating their own happiness highly also rated the target's happiness highly suggesting assumed similarity in both samples (Berlin: $b = 0.3225$, $SE = 0.0185$, $p < .001$; Vancouver: $b = 0.3657$, $SE = 0.0177$, $p < .001$). Perceiver happiness variability was not associated with how happy perceivers rated targets as, in either sample (Berlin: $b = 0.0582$, $SE = 0.0991$, $p = .559$; Vancouver: $b = –0.0139$, $SE = 0.1023$, $p = .892$). Target happiness variability was not associated with perceiver ratings of target happiness in the Berlin study ($b = –0.0970$, $SE = 0.0997$, $p = .333$), but it was associated with lower perceiver ratings of target happiness in the Vancouver study ($b = –0.2750$, $SE = 0.1022$, $p = .008$).

Primary hypotheses were tested using cross-level interactions, where perceiver and target intraindividual happiness variability were modeled as moderators of momentary pattern accuracy slopes (*Tables 2.2* and *2.3, Model C*)[2]. It was expected that targets higher in happiness variability would be more difficult to read, relative to those lower in happiness variability. Contrary to expectations, target happiness variability was unrelated to accuracy slopes (Berlin: $b = -0.0023$, $SE = 0.0023$, $p = .320$; Vancouver: $b = -0.0040$, $SE = 0.0034$, $p = .231$). It was also expected that perceivers high in happiness variability would be more accurate in rating their partner's happiness. Indeed, perceivers who were higher in happiness variability were more accurate, relative to perceivers lower in happiness variability; this effect was statistically significant in both samples (Berlin: $b = 0.0068$, $SE = 0.0022$, $p = .002$; Vancouver: $b = 0.0118$, $SE = 0.0033$, $p < .001$) and is illustrated in *Figure 2.2*.

Effect sizes were approximated using several approaches. The pseudo R-squared approach (Snijders & Bosker, 2012) was used to calculate overall explained variance for *Model C* (Berlin: *Pseudo* $R^2 = 0.52$; Vancouver: *Pseudo* $R^2 = 0.48$). Standardized simple slopes were calculated by z-standardizing the two predictors involved in the 2-way interaction; these standardized simple slopes were estimated for perceivers lower in happiness variability (one standard deviation below the mean; Vancouver: $b = 2.2963$, $SE = 0.4449$, $df = 5867$, $p < .001$; Berlin: $b = 2.7886$, $SE = 0.4855$, $df = 8623$, $p < .001$), compared to those higher in happiness variability (one standard deviation above the mean; Vancouver: $b = 4.9329$, $SE = 0.4436$, $df = 5867$, $p < .001$; Berlin: $b = 4.7403$, $SE = 0.4884$, $df = 8623$, $p < .001$). Changes in two standard

[2] Intra-individual affect variability can also be operationalized as an iMSSD (Jahng et al., 2008). For comparability with the existing literature, we focus on the iSD, but also estimated models using the iMSSD. Findings are similar regardless of which index was used.

deviations are recommended as a proxy for Cohen's *d* (Gelman, 2008), where predictors are calculated by z-standardizing using two standard deviations, and the coefficients may be interpreted as Cohen's *d* effect size measures. This approach resulted in smaller effects, with perceivers lower in happiness variability (Vancouver: $b = 0.0126$, $SE = 0.0029$, $df = 5867$, $p < .001$; Berlin: $b = 0.0110$, $SE = 0.0019$, $df = 8623$, $p < .001$) compared to those higher in happiness variability (Vancouver: $b = 0.0271$, $SE = 0.0030$, $df = 5867$, $p < .001$; Berlin: $b = 0.0187$, $SE = 0.0019$, $df = 5867$, $p < .001$). Using Cohen's f^2 as a measure of local effect size (Selya et al., 2012) also indicated small effects: 0.000001 (Vancouver), and less than 0.000001 (Berlin). Changes in residual variance relative to total variance were considered as an estimate of variance explained, where the percentage of change in residual variance relative to change in total variance from *Models B* to *C* was computed: adding the two-way interaction terms explained an additional 11.0% (Berlin) and 14.6% of variance (Vancouver). Of note, there was no variation at the couple level (see random effects, *Tables 2.2* and *2.3*). However, couple variance increases when mean target and perceiver happiness are excluded from models. In the context of the outcome (perceiver's rating of target happiness), which is conceptually tied to mean happiness, models may be 'oversaturated' with the inclusion of these predictors, although their inclusion is key to interpreting happiness variability, which is not independent from the mean.

Several key covariates were also considered. When perceivers were with targets, they rated target happiness as higher (Berlin: $b = 1.2055$, $SE = 0.3825$, $p = .002$; Vancouver: $b = 5.3126$, $SE = 0.4275$, $p < .001$). Neither perceiver (Berlin: $b = 0.0234$, $SE = 0.1852$, $p = .900$; Vancouver: $b = –0.0094$, $SE = 0.1470$, $p = .949$) nor target (Berlin: $b = –0.1341$, $SE = 0.1856$, $p = 472$; Vancouver: $b = 0.0696$, $SE = 0.1474$, $p = .638$) age was associated with perceiver's rating

of target happiness. Higher perceiver relationship satisfaction was associated with higher perceiver ratings of target happiness, but only in the Vancouver sample (b = 4.3168, SE = 0.9890, p < .001; Berlin: b = 1.1680, SE = 1.3055, p = .373). Women tended to rate their partner's happiness as higher than men, but only in the Berlin sample (Berlin*:* b = 3.1752, SE = 1.4278, p = .029; Vancouver: b = 1.6410, SE = 1.2965, p = .208). In the Vancouver sample, perceivers who completed the study in Mandarin rated their targets as happier, compared to perceivers who completed procedures in English (b = –5.0743, SE = 1.4941, p < .001). Higher perceiver mean happiness was associated with higher perceiver ratings of target happiness, in both samples (Berlin: b = 0.4170, SE = 0.0460, p < .001; Vancouver: b = 0.3617, SE = 0.0543, p < .001); however, target mean happiness was unrelated to perceiver ratings of target happiness (Berlin: b = 0.0296, SE = 0.0463, p = .524; Vancouver: b = –0.0781, SE = 0.0555, p = .163).

2.3.3 Exploratory Follow-Up Analyses

I further explored associations between partners sharing their feelings, pattern accuracy, and happiness variability, but had no specific a priori hypotheses. I added perceiver ratings of how much the target is sharing their feelings with them as a main effect and tested a respective three-way interaction in *Model D* (*Tables 2.2* and *2.3*). Perceivers rated targets as happier than usual when they also felt the target was sharing their feelings with them more than usual, across both samples (main effect of target sharing feelings; Berlin: b = 0.1944, SE = 0.0203, p < .001; Vancouver: b = 0.1266, SE = 0.0150, p < .001). Perceivers rated targets more accurately when they felt that the target was sharing their feelings more than usual (two-way interaction between target sharing feelings and pattern accuracy slope; Berlin: b = 0.0033, SE = 0.0006, p < .001; Vancouver: b = 0.0017, SE = 0.0006, p = .006). Whether targets were sharing their feelings more or less than usual did not moderate associations between target happiness variability and

perceiver ratings of target happiness (Vancouver: b = 0.0000, SE = 0.0001, p = .860; Berlin: b = 0.0000, SE = 0.0001, p = .590), nor associations between perceiver happiness variability and perceiver ratings of target happiness (b = 0.0002, SE = 0.0001, p = .073; Vancouver: b = 0.0000, SE = 0.0001, p = .644; *Figure 2.3*).

Table 2.1 Between-person means, standard deviations, and intercorrelations of key study variables (Berlin study, N = 214 individuals; Vancouver study, N = 234 individuals)

Variable	M *(SD)*	1	2	3	4	5	6	7	8
Berlin study									
1. Mean Rating of Partner Happiness	65.14 *(15.33)*								
2. Mean Rating of Own Happiness	66.95 *(15.38)*	.81**							
3. % Occasions Partner Present	0.76 *(0.24)*	.09	.03						
4. Happiness Variability (iSD)	15.49 *(6.39)*	–.16	–.27**	.03					
5. Age	75.21 *(3.82)*	.04	.05	–.01	–.07				
6. Gender	0.50 *(0.50)*	.03	–.11	.09	.23*	–.25**			
7. Mean Relationship Satisfaction	4.54 *(0.56)*	.20*	.16	.16	–.03	.23*	–.10		
8. Years Married	45.79 *(12.07)*	–.03	–.07	.11	.06	.34**	.00	.07	
Vancouver study									
1. Mean Rating of Partner Happiness	69.84 (*13.76*)								
2. Mean Rating of Own Happiness	74.20 *(13.31)*	.76**							
3. % Occasions Partner Present	0.78 (*0.18*	.18	.11						
4. Happiness Variability (iSD)	12.77 (*5.96*)	–.27**	–.35**	–.09					
5. Age	71.08 *(5.99)*	.08	.09	.27**	–.07				
6. Gender	0.50 *(0.50)*	.00	–.08	–.01	.11	–.21*			
7. Mean Relationship Satisfaction	4.17 *(0.70)*	.43**	.40**	.07	–.06	–.04	–.16		
8. Years Married	41.11 *(13.02)*	.00	.01	.21*	.00	.49**	–.00	–.05	
9. Language of Study Completion	0.72 *(0.45)*	.08	.21*	–.27**	.08	–.29**	.00	.42**	–.28**

Note. Gender: 0 = men, 1 = women. Happiness: 0 = “not at all” to 100 = “very much”. Number of partner present occasions were averaged across assessments. Relationship satisfaction: 1 = “not at all/poor” to 7 = “very often/excellent” (Berlin); and 1 = “not at all” to 5 = “very much” (Vancouver). Language of study completion: 0 = Mandarin, 1 = English. Degrees of freedom for significance testing is based on *N* (couples) – 2. * $p < .05$. ** $p < .01$.

Table 2.2 Mixed effect estimates (unstandardized) for multilevel models predicting perceiver's rating of target happiness (dependent variable), using maximum likelihood estimation (Berlin study, N = 8842 observations from 214 individuals)

	Berlin Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
Intercept (directional bias), δ_{000}	–3.8511* (1.5111)	8627	–4.5405** (0.9491)	8625	–4.6591** (0.9504)	8623	–4.2528** (0.9473)	8617
Level 1 (Momentary)								
Partner Present, β_1	2.0430** (0.4402)	8627	1.2214** (0.3825)	8625	1.2055** (0.3825)	8623	0.7014 (0.3765)	8617
Perceiver's Own Happiness Rating (assumed similarity slope), δ_{200}			0.3232** (0.0185)	8625	0.3225** (0.0185)	8623	0.2823** (0.0171)	8617
Target's Own Happiness Rating (pattern accuracy slope), δ_{300}			0.1608** (0.0157)	8625	0.1669** (0.0164)	8623	0.1613** (0.0161)	8617
Target Sharing Feelings, δ_{400}							0.1944** (0.0203)	8617
Level 2 (Person)								
Perceiver Age, γ_{01}	0.0802 (0.2905)	102	0.0110 (0.1851)	98	0.0234 (0.1852)	98	0.0481 (0.1847)	98
Target Age, γ_{02}	0.1300 (0.2909)	102	–0.1214 (0.1854)	98	–0.1341 (0.1856)	98	–0.1466 (0.1851)	98
Perceiver Gender, γ_{03}	0.9404 (1.5773)	102	3.0379* (1.4272)	98	3.1752* (1.4278)	98	3.3461* (1.4237)	98
Perceiver Relationship Satisfaction, γ_{04}	4.0468* (1.9189)	102	1.0827 (1.3055)	98	1.1680 (1.3055)	98	1.0569 (1.3017)	98
Target Relationship Satisfaction, γ_{05}	2.6283 (1.9187)	102	0.5386 (1.3059)	98	0.4702 (1.3061)	98	0.5738 (1.3022)	98
Perceiver Happiness iSD, γ_{06}			0.0753 (0.0990)	98	0.0582 (0.0991)	98	0.0612 (0.0988)	98

	Berlin Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
Target Happiness iSD, γ_{07}			–0.1029 (0.0997)	98	–0.0970 (0.0997)	98	–0.1011 (0.0995)	98
Perceiver Mean Happiness, γ_{08}			0.4165** (0.0459)	98	0.4170** (0.0460)	98	0.4511** (0.0457)	98
Target Mean Happiness, γ_{09}			0.0410 (0.0457)	98	0.0296 (0.0463)	98	0.0334 (0.0460)	98
Interactions								
Target's Own Happiness Rating (pattern accuracy slope) x Target Happiness iSD, γ_{31}					–0.0023 (0.0023)	8623	–0.0021 (0.0022)	8617
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings, γ_{50}							0.0033** (0.0006)	8617
Target Sharing Feelings x Target Happiness iSD, γ_{41}							–0.0005 (0.0030)	8617
Target's Own Happiness Rating (pattern accuracy slope) x Perceiver Happiness iSD, γ_{32}					0.0068 (0.0022)**	8623	0.0070** (0.0022)	8617
Target Sharing Feelings x Perceiver Happiness iSD, γ_{42}							–0.0034 (0.0029)	8617
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings x Target Happiness iSD, γ_{51}							0.0000 (0.0001)	8617
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings x Perceiver Happiness iSD, γ_{52}							0.0002 (0.0001)	8617
Level 3 (Couple)								
Years Married, δ_{0001}	–0.0883 (0.1142)	105	0.0561 (0.0522)	105	0.0584 (0.0523)	105	0.0571 (0.0521)	105

	Berlin Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
Random Effects	σ^2		σ^2		σ^2		σ^2	
Between-Person								
Variance Intercept, u_{0j}	94.7225		57.8422		57.9938		58.4105	
Variance Perceiver's Own Happiness Rating, u_{2j}			0.0220		0.0218		0.0197	
Variance Target's Own Happiness Rating, u_{3j}			0.0175		0.0142		0.0141	
Variance Target Sharing Feelings, u_{4j}							0.0275	
Between-Couple								
Variance Intercept, v_{00k}	115.6982		0.0007		0.0004		0.0003	
Variance Perceiver's Own Happiness Rating, v_{20k}			0.0140		0.0141		0.0100	
Variance Target's Own Happiness Rating, v_{30k}			0.0067		0.0081		0.0076	
Variance Target Sharing Feelings, v_{40k}							0.0081	
Within-Person								
Residual Variance, r_{ijk}	235.5669		163.1393		163.1577		151.1579	
Autocorrelation	0.0603		0.0287		0.0288		0.0264	

Note. Gender: 0 = men, 1 = women. Happiness: 0 = "not at all" to 100 = "very much". Partner presence: 0 = "not present", 1 = "present". Relationship satisfaction: 1 = "very bad" to 5 = "very good". * $p < .05$. ** $p < .01$.

Table 2.3 Mixed effect estimates (unstandardized) for multilevel models predicting perceiver's rating of target happiness (dependent variable), using maximum likelihood estimation (Vancouver study, N = 6106 observations from 234 individuals)

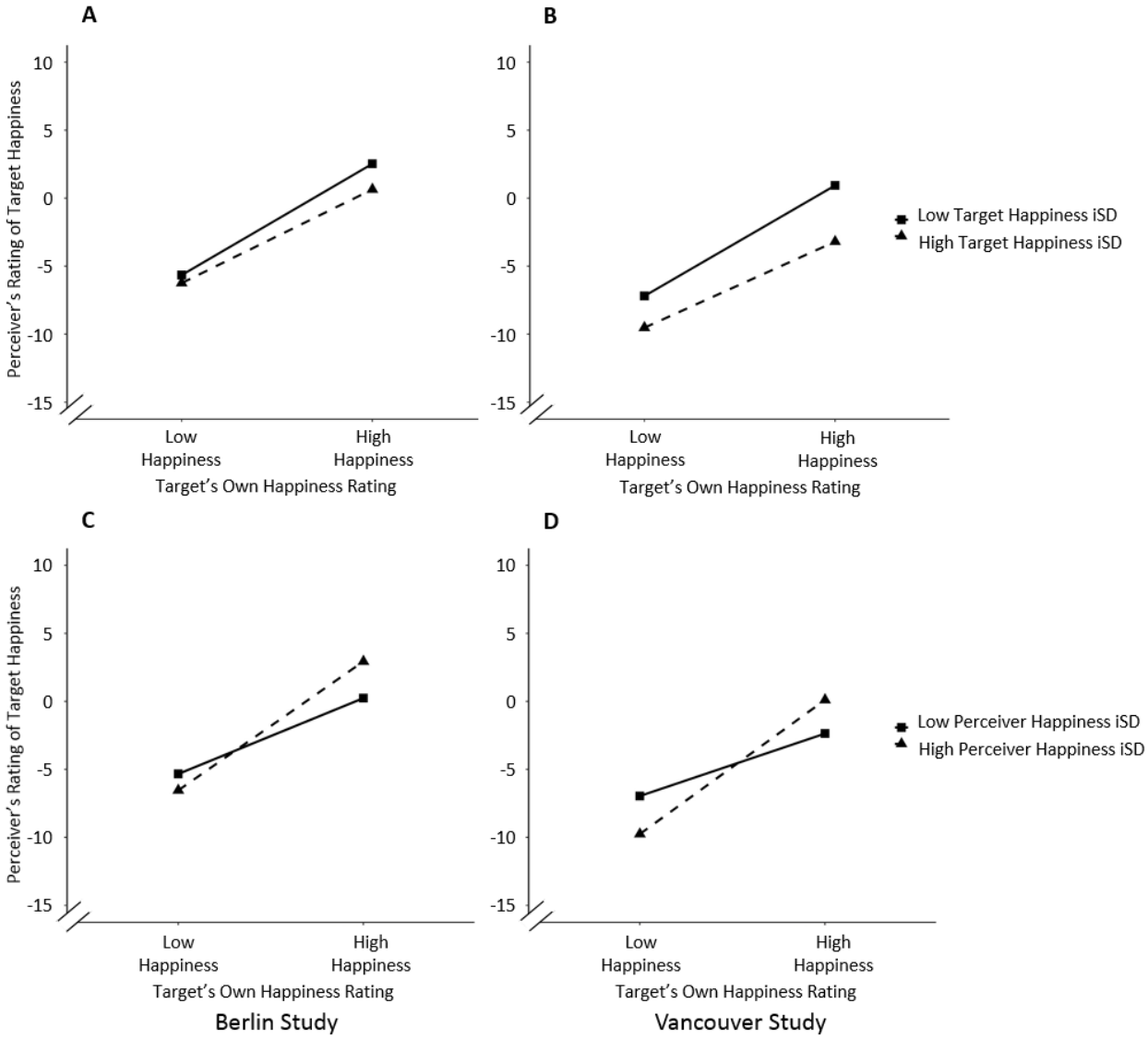
	Vancouver Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
Intercept (directional bias), δ_{000}	–6.7917** (2.1363)	5871	–5.9613** (1.4082)	5869	–6.0464** (1.4121)	5867	–4.3085** (1.4108)	5861
Level 1 (Momentary)								
Partner Present, β_1	5.6066** (0.4876)	5871	5.3019** (0.4278)	5869	5.3126** (0.4275)	5867	3.2162** (0.4426)	5861
Perceiver's Own Happiness Rating (assumed similarity slope), δ_{200}			0.3686** (0.0178)	5869	0.3657** (0.0177)	5867	0.3246** (0.0171)	5861
Target's Own Happiness Rating (pattern accuracy slope), δ_{300}			0.1774** (0.0215)	5869	0.1896** (0.0227)	5867	0.1724** (0.0206)	5861
Target Sharing Feelings, δ_{400}							0.1266** (0.0150)	5861
Level 2 (Person)								
Perceiver Age, γ_{001}	0.2388 (0.1867)	112	–0.0076 (0.1466)	108	–0.0094 (0.1470)	108	–0.0041 (0.1463)	108
Target Age, γ_{002}	0.0246 (0.1867)	112	0.0602 (0.1470)	108	0.0696 (0.1474)	108	0.0741 (0.1466)	108
Perceiver Gender, γ_{003}	1.7007 (1.5945)	112	1.5265 (1.2919)	108	1.6410 (1.2965)	108	1.6811 (1.2923)	108
Perceiver Relationship Satisfaction, γ_{004}	8.0787** (1.2883)	112	4.1519** (0.9852)	108	4.3168** (0.9890)	108	4.2912** (0.9845)	108
Target Relationship Satisfaction, γ_{005}	3.3112* (1.2882)	112	0.0086 (0.9813)	108	–0.0108 (0.9845)	108	0.1334 (0.9807)	108
Perceiver Happiness iSD, γ_{006}			0.0036	108	–0.0139	108	–0.0330	108

	Vancouver Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
			(0.1019)		(0.1023)		(0.1019)	
Target Happiness iSD, γ_{007}			–0.2857** (0.1019)	108	–0.2750** (0.1022)	108	–0.2684** (0.1018)	108
Perceiver Mean Happiness, γ_{008}			0.3609** (0.0541)	108	0.3617** (0.0543)	108	0.3922** (0.0538)	108
Target Mean Happiness, γ_{009}			–0.0612 (0.0546)	108	–0.0781 (0.0555)	108	–0.0546 (0.0550)	108
Interactions								
Target's Own Happiness Rating (pattern accuracy slope) x Target Happiness iSD, γ_{31}					–0.0040 (0.0034)	5867	–0.0033 (0.0031)	5861
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings, γ_{50}							0.0017** (0.0006)	5861
Target Sharing Feelings x Target Happiness iSD, γ_{41}							–0.0008 (0.0024)	5861
Target's Own Happiness Rating (pattern accuracy slope) x Perceiver Happiness iSD, γ_{32}					0.0118** (0.0033)	5867	0.0126** (0.0031)	5861
Target Sharing Feelings x Perceiver Happiness iSD, γ_{42}							–0.0017 (0.0023)	5861
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings x Target Happiness iSD, γ_{51}							0.0000 (0.0001)	5861
Target's Own Happiness Rating (pattern accuracy slope) x Target Sharing Feelings x Perceiver Happiness iSD, γ_{52}							0.0000 (0.0001)	5861
Level 3 (Couple)								
Years Married, δ_{0001}	–0.0875	114	–0.0797	114	–0.0822	114	–0.0775	114

	Vancouver Study							
	Model A		Model B		Model C		Model D	
	b (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*	*b* (*SE*)	*df*
	(0.0814)		(0.0494)		(0.0495)		(0.0494)	
Language of Study Completion, δ_{0002}	–4.1689* (2.4055)	114	–4.9116** (1.4882)	114	–5.0743** (1.4941)	114	–5.2521** (1.4883)	114
Random Effects	σ^2		σ^2		σ^2		σ^2	
Between-Person								
Variance Intercept, u_{0j}	90.1398		53.4179		53.9925		55.0031	
Variance Perceiver's Own Happiness Rating, u_{2jk}			0.0277		0.0272		0.0207	
Variance Target's Own Happiness Rating, u_{3jk}			0.0440		0.0374		0.0328	
Variance Target Sharing Feelings, u_{4jk}							0.0205	
Between-Couple								
Variance Intercept, v_{00k}	40.5926		0.0000		0.0000		0.0000	
Variance Perceiver's Own Happiness Rating, v_{20k}			0.0000		0.0000		0.0016	
Variance Target's Own Happiness Rating, v_{30k}			0.0071		0.0096		0.0033	
Variance Target Sharing Feelings, v_{40k}							0.0015	
Within-Person								
Residual Variance, r_{ijk}	214.6011		153.1476		153.0748		140.3694	
Autocorrelation	0.0239		0.0126		0.0127		0.0098	

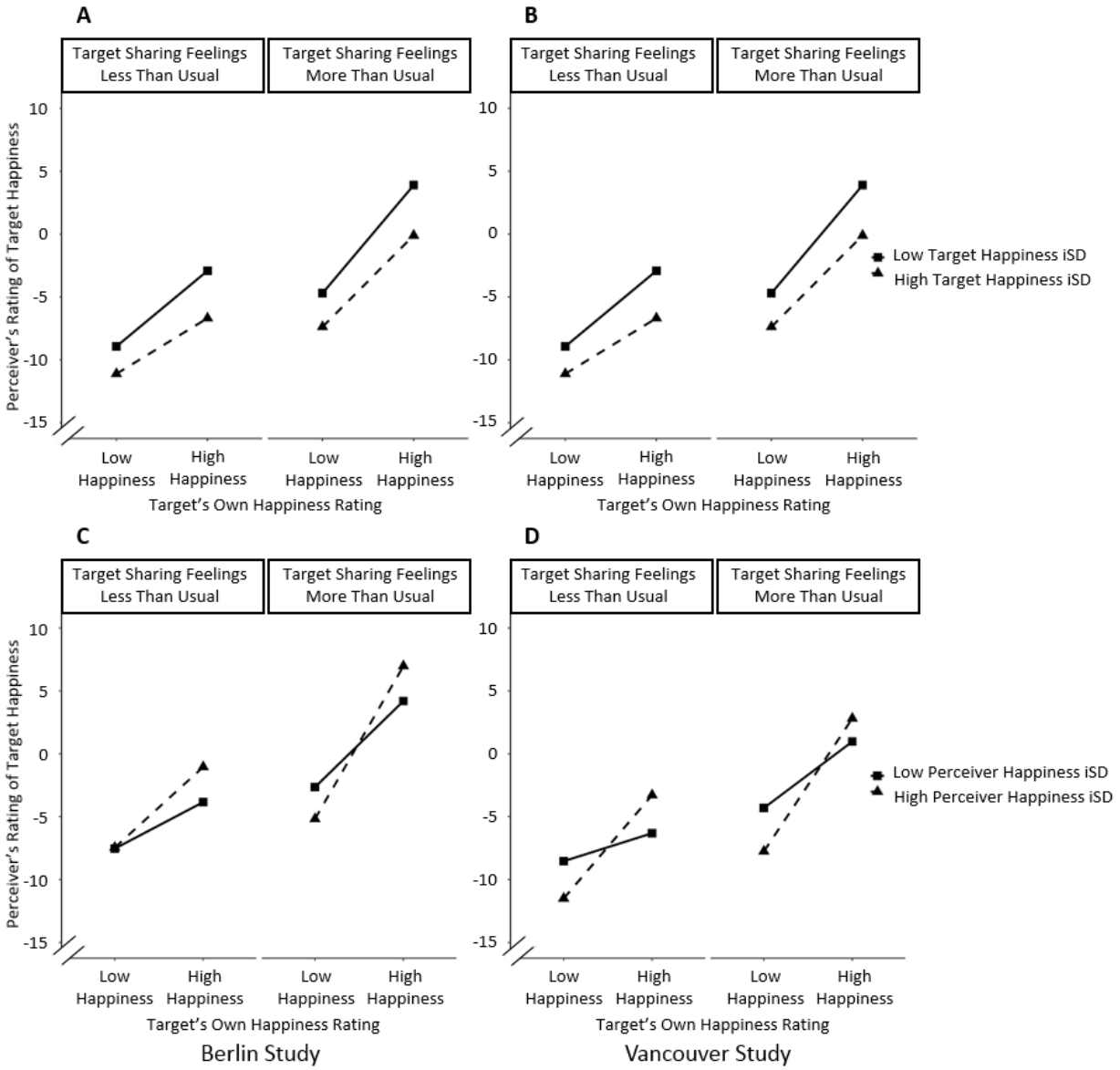
Note. Gender: 0 = men, 1 = women. Happiness: 0 = "not at all" to 100 = "very much". Partner presence: 0 = "not present", 1 = "present". Relationship satisfaction: 1 = "not at all" to 5 = "very much". Language of study completion: 0 = Mandarin, 1 = English. * $p < .05$. ** $p < .01$.

Figure 2.2 Illustration of two-way interaction effects (Model C)



Note. Pattern accuracy slopes (i.e. associations between perceiver's rating of target happiness and target's own happiness) are depicted at different levels of target and perceiver happiness variability (iSD). All depicted variables were continuous, and shown at high and low levels ($M \pm 1\ SD$). Intercepts were adjusted by coding dichotomous variables as -1 and +1 to reflect the entire sample, for illustrative purposes. Negative intercept values indicate underestimation of target happiness, while positive values indicate overestimation (Kenny & West, 2011). Target happiness variability was not associated with pattern accuracy (panels A and B). Perceivers high in happiness variability more accurately understood target happiness, in both studies (panels C and D).

Figure 2.3 Illustration of three-way interaction effects (Model D)



Note. Pattern accuracy slopes (i.e. associations between perceiver's rating of target happiness and target's own happiness) are depicted at different levels of target and perceiver happiness variability (iSD), as a function of the perceiver's rating of how much the target is sharing their feelings at that moment. All depicted variables were continuous, and shown at high and low levels ($M \pm 1\ SD$). Intercepts were adjusted by coding dichotomous variables as -1 and +1 to reflect the entire sample, for illustrative purposes. Negative intercept values indicate underestimation of target happiness, while positive values indicate overestimation (Kenny & West, 2011). Sharing feelings was not found to moderate associations between target happiness variability and pattern accuracy in either study (panels A and B). Associations between perceiver happiness variability and accuracy were not moderated by the extent to which the target was sharing their feelings, in either study (panels C and D).

2.4 Discussion

This study examined the role of happiness variability for empathic accuracy in older couples as they engaged in their daily life routines, using coordinated analyses across two data sets. Findings supported my expectation that pattern accuracy is enhanced when perceivers are high in happiness variability. Exploratory follow-up analyses suggested that these associations are not moderated by the extent to which partners share their feelings with each other. Contrary to expectations, there was no evidence for attenuated pattern accuracy when targets themselves are high in happiness variability, in either sample.

Assumed similarity plays an important role in perceptions of partner happiness. In this study, perceivers assumed that changes in their partner's happiness were similar to their own (West & Kenny, 2011). Beyond this assumed similarity in happiness, perceiver ratings of their spouse's happiness were significantly and positively associated with their spouse's own happiness ratings, indicating that partners' correct inference about each other's happiness was greater than chance. Interestingly, older adults underestimated their partner's happiness on average, across both samples. Hülür et al. (2016) previously also found that older adults on average underestimated their partner's happiness in daily life (using a 'scatter accuracy' index). In line with central tenets of socioemotional selectivity theory that older adults are motivated to focus on positive emotional experiences (Carstensen et al., 2003), older adults generally paid attention to the happiness of their partners; however, they perceived their happiness as lower than it actually was. These findings might be understood in light of experimental findings suggesting that it is more difficult to read older adults' affect, versus younger adults' affect (Ruffman et al., 2019), although it must be noted that these studies were based on unrelated dyads. Importantly, accuracy is not mutually exclusive to bias (West & Kenny, 2011) – older

adults can be generally accurate about how happy their partner is, while systematically underestimating their happiness.

High perceiver happiness variability was associated with steeper pattern accuracy slopes in both samples. The literature on accuracy and perceiver affect variability is scarce, although there is conceptual overlap between affect variability and neuroticism (of which a subcomponent is emotional instability; Eid & Diener, 1999). There is evidence that older adults high in neuroticism pay more attention to the ups and downs of their spouses, which may facilitate everyday problem-solving (Lay & Hoppmann, 2014). The emotional instability that is associated with neuroticism may be what drives this increased vigilance to the emotional states of one's partner. Although the effect size was very small, these findings provide initial evidence across two different samples that perceivers high in happiness variability similarly show better accuracy regarding spousal happiness. I did not directly test attention, but speculate that this may be facilitated by increased attention to changes in spouse's happiness. Another potential explanation is that individuals high in happiness variability are also more aware of their own emotions, and the emotional experiences of others. For example, individuals who are able to better differentiate their own emotions are also more accurate at detecting others' positive emotional experiences (Erbas et al., 2016).

I conducted exploratory follow-up analyses to better understand underlying mechanisms. Specifically, perceiver ratings of target happiness co-varied with target's rating of own happiness when the target was sharing their feelings more than usual, across both samples. The Realistic Accuracy Model (Funder, 1995) suggests that cues must be provided by targets and detected by perceivers. Cues about changes in partner happiness may be more salient and easier to detect if the partner makes a conscious effort to share their feelings. Associations between intra-

individual happiness variability (target or perceiver) and perceiver ratings of target happiness were not moderated by whether the target was sharing their feelings more than usual or not, in either sample.

Contrary to expectations, target happiness variability was not associated with pattern accuracy, in either sample. This finding replicates previous research conducted with the same sample but a different focus (Berlin; Hülür et al., 2016). The existing literature largely focuses on younger samples (Biesanz & West, 2000; Lazarus et al., 2019), and perhaps such findings do not translate to older adults who have been married on average for many years. For example, older spouses likely have a long history of reading each other's emotions, and likely draw on that wealth of experience to infer their partners' emotions (Rauers et al., 2013). Perhaps partners are easier to read if one has a long history of observing a partner across many different situations, regardless of their happiness variability. Alternatively, there are known age differences in readability of emotions, where older adults are generally harder to read compared to younger adults (Ruffman et al., 2019).

Analyses generally replicated in both samples, despite notable differences across studies. For example, positive affect variability may be sensitive to age-related changes (Röcke et al., 2009), and although the samples only differed in age by four years on average, age-related challenges differ between young- and old-old age groups (P. B. Baltes & Smith, 2003). Further, social desirability of happiness differs across cultures: North Americans may value happiness more than Western Europeans and thus be more prone to overstating their current happiness (Ouweneel & Veenhoven, 1991). However, diverse cultural backgrounds in North America may uniquely shape values regarding ideal affect, relative to individuals living in their heritage culture (Tsai et al., 2006). Also, the designs differentially captured fast-moving emotions: the

Berlin study included 1.5 times more assessment points than the Vancouver study, potentially more precisely capturing changes (as evidenced by higher reliability of happiness variability), although also potentially risking fatigue and in turn amplified measurement error. The current research provides initial evidence for perceiver happiness variability moderating pattern accuracy in couples, across different phases of older adulthood, North American and Western European cultures, and differential measurement point timing.

2.4.1 Limitations and Future Directions

Coordinated analyses were used to examine the role of happiness variability for empathic accuracy across two older couple samples that differed in their cultural heritage, mean age, and sampling design (Hofer & Piccinin, 2009). Replication is often difficult due to the cost and time involved in collecting data like those presented here, but it contributes to a better understanding of the robustness of findings.

Nevertheless, there are also a number of limitations. Happiness variability is a broad construct that captures the amplitude of change in happiness across all situations encountered during a week of daily life assessments. Hence, specific emotional responses are not distinguished, such as anticipation, rumination, reactivity, or inertia (see Ong & Ram, 2017 for a review of different affect dynamics). Denser assessment schedules and larger sample sizes are required to capture specific patterns of emotional responding; affect variability is less stringent in allowing the 'signal' of emotional responding to be detected. Future research would benefit from specific conceptualizations of emotion dynamics in relation to empathic accuracy to pinpoint the boundaries of the current findings and underlying mechanisms. There are also many ways to capture affect variability. The intra-individual mean successive squared difference (iMSSD; Jahng et al., 2008) has been proposed as a more precise measure of affect variability: it captures

temporal dependency across assessment points, and the amplitude and frequency of affective change (Ebner-Priemer et al., 2007). Although the current findings replicate regardless of whether the iSD or iMSSD are used, future investigations should consider the conceptual meanings underpinning affect variability measures.

These findings are based on a single-item measure of affect that focuses on happiness, because positive affect is more variable relative to negative affect in older age (Röcke et al., 2009). Although between-person metrics are not easily adapted to reliability computations of within-person affect variation (Brose et al., 2019), including a wider range of pertinent affect items to average across would improve reliability of affect indices at each level of analysis (Wilhelm & Schoebi, 2007). These findings should also be extended by examining accuracy and variability across a range of affective states. I speculate that the co-occurrence of positive and negative states may help older partners savor the moment, but also support each other during problem-solving. It would also be interesting to investigate whether partners differentially pay attention to high- versus low-arousal positive emotions in their partners.

Further routes for inquiry may include how specific emotional experiences relate to one's partnership. For example, Ferrer et al. (2013) examined intra-individual variability of daily affect in a sample of couples aged 50 and above, by asking questions such as how happy, trusted, socially supported, trapped, lonely, and deceived each partner felt that day in their relationship. Integrating these ideas with the current line of work may involve considering empathic accuracy not only with regards to understanding how one's partner is feeling, but also how one's partner is feeling about the relationship, coping with daily problems, and progress towards goals. Such investigations would be useful for tapping into how partners can effectively function and support each other in older age.

There are also limitations in study design and participant sampling that must be considered. Both samples were community-dwelling and well-functioning enough to be able to participate in time-intensive studies. Couples were in satisfying marital relationships and showed good self-rated health. It is an open question whether findings generalize to older adults who live under more challenging circumstances. Detecting changes in emotional experiences may become even more pertinent for partners who are coping with health or relationship issues. Further, emotional experiences change quickly and by fixing the timing of assessment points, we risk missing key changes, generalizing to other times, or participants adjusting their current states in anticipation of being asked about their feelings. However, ideal designs cannot discount feasibility and participant demands (Gerstorf et al., 2014; Hoppmann & Riediger, 2009; Scollon et al., 2009), and increasing or randomizing assessments risks adherence to study protocols. Importantly, samples may become even more selective with increased demands on participants. Spreading assessment points evenly and predictably throughout the day is one strategy that may minimize unwelcome surprises to participants while capturing daily life experiences. It is also important to note that all findings are correlational, and hence bidirectional with unknown third-variables influences (e.g. fatigue).

Lastly, but importantly, I recognize that the effect size for the two-way interaction between perceiver happiness variability and pattern accuracy was small. Small effect sizes are common in observational studies of daily life, especially compared to those obtained in controlled experimental settings. However, the literature on emotional experiences in daily life also highlights that these small effects can accumulate into long-term health consequences (for example, see Piazza et al., 2013). The current approach maximizes ecological validity, but should be complemented by findings obtained in the laboratory. I am not aware of a study design

that manipulates happiness variability, but well-established laboratory paradigms for empathic accuracy (e.g. unstructured dyadic interaction paradigm, the standard empathic accuracy assessment procedure; Ickes et al., 1990) represent an interesting direction for future investigations.

2.4.2 Conclusions

Taken together, this study provides initial evidence that perceivers show better accuracy when they themselves are high in happiness variability, but no worse momentary pattern accuracy for targets high (or low) in happiness variability. This chapter extends previous evidence by connecting intra-individual affect variability and time-varying pattern accuracy, specifically with regards to happiness, using naturalistic data provided by two samples of community-dwelling older couples. To understand how everyday emotional experiences may also shape health-relevant processes, it is necessary to link them with physiological correlates. This was the focus of Chapter 3.

Chapter 3: Time-Varying Associations between Everyday Sadness, Contentment, and Cortisol are Moderated by Sharing Feelings in Older Adult Couples

3.1 Introduction

Older adults often prioritize meaningful emotional experiences and social relationships in the face of limited future time perspectives (Socioemotional Selectivity Theory (SST); Carstensen et al., 2003; Carstensen et al., 1999). Marriage is one of the most central relationships in older age, and a primary social context in which emotions are experienced and shared (Larson & Almeida, 1999; Michalowski et al., 2018; Rauers et al., 2013). The transmission of emotions in couples can play a role in turning on the Hypothalamus-Pituitary-Adrenal (HPA) axis to ultimately regulate cortisol secretion (Slatcher et al., 2011), thereby representing one potential pathway through which everyday experiences 'get under the skin' and accumulate into longer term outcomes. The aim of the current study was to examine the time-varying associations between everyday emotional experiences and cortisol in older adult couples, taking into account not only one's own emotional experiences, but also those of one's partner, as well as the extent to which partners reported sharing their emotions in everyday life.

Older adulthood is a developmental phase with unique challenges as well as opportunities, relative to earlier phases in life. On the one hand, limited resources and health challenges become more common (Lindenberger & P. B. Baltes, 1997). On the other hand, perceptions that future time is limited may be associated with a prioritization of emotionally meaningful close relationships (SST; Carstensen et al., 2003; Carstensen et al., 1999). Furthermore, older adults seem to be better at regulating their negative emotions based on their

past experiences, resulting in improved emotion regulation relative to earlier life phases (Blanchard-Fields, 2007; Blanchard-Fields et al., 2007). Age differences in emotion regulation may be moderated, but not fully accounted for, by individual differences (e.g. affect, personality), aspects of stimuli, and types of emotions (e.g. anger versus sadness; Stanley & Isaacowitz, 2014). Integrating age-related gains and losses, the Strength and Vulnerability Integration (SAVI; Charles, 2010; Charles & Piazza, 2009) model posits that compared to younger and middle-aged adults, older adults are better at regulating negative emotions, but that they also have more difficulty downregulating physiological reactions when that is not possible, due to age-related wear and tear in biological systems (Agrigroaci et al., 2013; Sapolsky et al., 1986). In other words, older adults are better able to draw on a wealth of life experiences to regulate their emotions and also avoid situations that are likely to elicit negative emotions (Gross et al., 1997; Stawski et al., 2013; Zautra et al., 1991), perhaps because they are aware of their consequences. Hence, age-related increases in motivation to maintain affective well-being, improved emotion regulation, and increased situation selection are protective in abating the costs of sustained physiological arousal that co-occur with negative emotional experiences (Charles, 2010).

3.1.1 Emotional Experiences in Older Adulthood

Emotional experiences represent an important underlying mechanism in the well-established associations between close relationships and health (Farrell et al., 2018; Smith & Weihs, 2019; Uchino & Way, 2017). Generally, positive emotions are beneficial for health (Cohen & Pressman, 2006; Fredrickson, 2000, 2001; Kiecolt-Glaser et al., 2002), while negative emotions are more likely to be detrimental (although they have adaptive purposes; Fredrickson, 2000, 2001; Kunzmann et al., 2019). Most research has looked at the health-relevance of broad

positive and negative affect composites, which may be limiting considering that different discrete affective states serve different functions.

A functionalist perspective to emotions suggests that discrete emotions serve different purposes (Keltner & Gross, 1999) and differentially impact health-related processes in close social relationships (Levenson, 2019). In fact, research based on unrelated individuals suggests that discrete emotions are particularly illuminating for the study of aging (Kunzmann et al., 2014). For example, anger and sadness have a special spotlight in the developmental literature, where anger is considered particularly detrimental for healthy aging, but sadness may be adaptive in some cases (Barlow et al., 2019). Laboratory studies with lifespan samples show that older adults tend to experience equivalent or higher levels of sadness, but far less anger, relative to younger adults (Kunzmann & Gruhn, 2005; Kunzmann et al., 2013; Kunzmann et al., 2017; Seider et al., 2011). From a lifespan functionalist perspective, sadness is an affective state that is unpleasant in the moment, but facilitates disengagement from unattainable goals in the face of resource loss (Haase et al., 2013; Wrosch & Heckhausen, 1999). Given the increased likelihood and frequency of age-related losses, sadness represents a particularly salient affective state in older adulthood.

Despite a focus on negative affect in extant literature, there is a growing recognition of the role of positive emotions for health (Cohen & Pressman, 2006; Fredrickson, 2001; Steptoe et al., 2005). Given that older adults prefer low arousal and positively valenced affective states (Kessler & Staudinger, 2009; Scheibe et al., 2013), contentment may deserve more attention than it has received in the developmental literature. Indeed, the Broaden-and-Build Theory of positive emotions points to contentment as a discrete positive emotion that serves the adaptive purpose of broadening one’s thought-action repertoire by facilitating one’s ability to savor life as it currently

is, and ultimately building personal resources that can be drawn on to cope with future challenges (Fredrickson, 2001). Given that low arousal positive emotions are especially pertinent with older age (Kessler & Staudinger, 2009; Scheibe et al., 2013), contentment may be an especially salient discrete emotion to examine in the daily lives of older adults.

3.1.2 Cortisol Secretion as a Physiological Pathway in Associations Between Emotions and Health

The Hypothalamus-Pituitary-Adrenal (HPA) axis plays a key role in shaping longer term health outcomes (Hoppmann & Michalowski, 2015; Piazza et al., 2010). The HPA axis is a neuroendocrine system that regulates the release of cortisol, a glucocorticoid hormone that increases the availability of glucose while suppressing the immune system, sleep, and digestion, and can be reliably measured in saliva. Cortisol has a predictable diurnal rhythm, with a steep rise in the first 30 minutes after waking, followed by a slow decline throughout the remainder of the day. In addition, cortisol also fluctuates in response to time-varying circumstances, with older adults generally showing more pronounced responses to stressors, relative to younger adults (Agrigroaci et al., 2013; Otte et al., 2005).

Greater negative affect is generally associated with higher corresponding cortisol levels (Adam et al., 2006; Smyth et al., 1998), although not all studies find this association (e.g. Polk et al., 2005). On the other hand, positive affect is protective and linked with lower concurrent cortisol levels (Nater et al., 2010; Smyth et al., 1998; Steptoe & Wardle, 2005; Steptoe et al., 2007; Steptoe et al., 2005). In line with the SAVI model (Charles, 2010; Charles & Piazza, 2009), linkages between positive and negative affect and cortisol may be particularly strong in older age (Piazza et al., 2013). Given the relatively higher frequency of low arousal affective states in older adulthood (Kessler & Staudinger, 2009; Scheibe et al., 2013), sadness and

contentment should be especially pertinent emotional experiences in older adults. I therefore expected that within-person increases in sadness would be associated with concurrent increases in cortisol, whereas within-person increases in contentment would be associated with concurrent decreases in cortisol.

3.1.3 Marriage as a Key Social Context

Spouses typically have a long history of shared experiences in older age, and act as each other's first line of defense in managing challenges of daily life (Berg & Upchurch, 2007). Emotional experiences are often transmitted and co-vary between spouses (Hoppmann et al., 2011; Larson & Almeida, 1999; Michalowski et al., 2018), and hence, looking beyond the individual and towards the marital context can provide valuable insights into the affect-stress nexus in old age (Hoppmann & Gerstorf, 2009). Indeed, certain couple dynamics may be especially protective against increases in cortisol. For example, in younger and middle-aged adult samples, greater levels of intimacy are related to lower daily levels of cortisol (Ditzen et al., 2008) and accelerated stressor-induced cortisol recovery (Ditzen et al., 2019). Further, dyadic considerations of cortisol dynamics within couples have demonstrated that spouses often show cortisol linkage or synchrony (Pauly et al., in press; Saxbe et al., 2019; Timmons et al., 2015).

However, few investigations have examined the role of emotional dynamics within marriage on own and spousal cortisol responses in everyday life. One notable exception is a study by Slatcher et al. (2011), where using ecological momentary assessment data from a sample of healthy, working married couples with small children, they found that higher trait marital disclosure (operationalized as the extent to which one shares one's thoughts and feelings with one's spouse) buffered momentary associations between work worries and cortisol. More specifically, wives who generally disclosed their thoughts and feelings to their partner to a

greater extent showed attenuated concurrent associations between momentary cortisol and work worries, relative to wives who generally disclosed to a lesser extent. Importantly, while both husbands and wives who had greater work worries also showed elevated cortisol 1–1.5 hours later (actor effect), only wives showed elevated cortisol 1–1.5 hours later in response to their husbands' work worries as well (partner effect). Hence, in this study, wives not only showed cortisol responses to their own work worries, but also to their spouse's work worries, although high marital disclosure mitigated concurrent associations between their own work worries and cortisol.

Given changed relationship dynamics in long-term marriages post-retirement, it is unclear whether gender differences would emerge to the same degree in older adult couples as in middle-aged couples. In fact, previous research suggests that the well-known gender gap in depressive symptoms (where depressive symptoms are more commonly seen in women relative to men; Mirowsky, 1996) actually narrows in older adulthood, and reverses to the extent that in the very-old, men actually display more depressive symptoms relative to women (Chui et al., 2015). Moreover, discrete low arousal emotions such as sadness and contentment are likely more relevant than work worries (e.g. Slatcher et al., 2011) in older age, making them prime candidates for examining dyadic linkages between emotional experiences and cortisol levels in older couples. From a SAVI model (Charles, 2010) perspective, sharing emotions with one's spouse may be beneficial, especially if they are positive (such as contentment; representing a social resource), but being 'let in' on sadness can also mean being exposed to momentary negative emotional experiences (representing a vulnerability factor). Hence, a spouse sharing their contentment may be reflected in one's own concurrently reduced cortisol levels, but having

a spouse share their sadness should be associated with one's own concurrently increased cortisol levels.

3.1.4 The Current Study

The purpose of the current study was to contextualize associations between affective experiences and salivary cortisol in the everyday lives of older couples by taking the perspectives of both partners into account. I focused on two discrete emotions specifically, in order to capture prominent affective states pertinent in old age: sadness and contentment. I also examined momentary fluctuations in perceptions of shared feelings as a moderator in associations between partner affect and one's own momentary cortisol levels. The first hypothesis was directed at replicating previous findings regarding associations between one's own affective state and one's own cortisol levels. I expected that increases in one's own negative affect (e.g. sadness) would be associated with higher momentary cortisol, while increases in one's own positive affect (e.g. contentment) would be associated with reduced momentary cortisol. The focus of the second hypothesis was to build on previous findings that intimacy and marital disclosure buffer cortisol reactivity to negative affective states, by focusing on the role of one's momentary perceptions that one's partner is sharing their feelings on one's own cortisol level. I expected that on average, greater perceptions of shared feelings would be associated with decreases in one's own cortisol levels. Additionally, the third hypothesis examined the moderating role of shared feelings on associations between one's partner's affective state and one's own cortisol level. I expected that one's partner's contentment would be associated with one's own lower cortisol level, and that one's partner's sadness would be associated with one's own elevated cortisol level, especially when perceptions of shared feelings are higher than usual.

Several situational, individual, and couple covariates that are relevant to cortisol in older couples were also taken into account, in order to facilitate interpretations of key associations. Beyond momentary and overall mean levels, fluctuations in emotional experiences (i.e. affect variability; Ebner-Priemer et al., 2007; Ram & Gerstorf, 2009) can also play a role in daily cortisol profiles. For example, in middle-aged and older adults, high negative affect variability has been associated with blunted next-day cortisol awakening response (Proulx et al., 2017), and high positive affect variability with lower momentary levels and steeper slopes of cortisol in daily life (Human et al., 2015). Additionally, age, gender, partner presence, cultural heritage, and time-varying covariates that may influence salivary cortisol measurements (e.g. caffeine intake, food intake, and prior physical activity) were considered as covariates (Strahler et al., 2017).

3.2 Methods

3.2.1 Participants and Procedures

The current study used data from a larger project on spousal health dynamics in older age (see Ashe et al., 2019; Michalowski et al., 2020; Pauly, Keller, et al., 2019; Pauly, Michalowski, et al., 2019 for more details). The larger project recruited 129 community-dwelling couples who were cohabiting and aged at least 60 years, through community advertisements and existing subject pools. Participants provided repeated daily life assessments, and were invited to also participate in annual follow-ups, although daily life assessments were only provided in the first year of participation. As part of the daily life assessments, a subsample of couples where neither partner had thyroid dysfunction and other conditions impacting HPA functioning were asked to provide salivary cortisol samples. Only couples who were eligible to provide salivary cortisol and data from year one were part of the current study. All participants provided informed

consent, with ethics approval granted from the clinical research ethics board of the University of British Columbia, and received $100 CAD each as reimbursement.

The final sample included 84 couples (*M* age = 71.08, *SD* = 6.02, *range* = 60 - 87; 58.9% Caucasian, 36.9% East Asian; *M* self-rated health = 3.25, *SD* = 0.96, 1 = "poor" to 5 = "excellent"; 65.5% with at least some college education). From the original sample, 9 couples were excluded because they did not provide daily life assessments. Any couples where one or both partners had conditions related to HPA functioning were not asked to provide salivary cortisol (*n* = 28). Of the couples who did provide salivary cortisol, four were excluded because they had highly elevated cortisol due to other health conditions, and two due to missing cortisol data. One couple was also excluded due to language difficulties (*n* = 1), and another because one partner was missing time since waking on all assessment points (*n* = 1).

The study was offered in either English, Mandarin or Cantonese, to be inclusive of local demographics; 29.8% of couples completed the study in Mandarin, with the rest completing procedures in English. Spouses belonging to the same couple completed study procedures in the same language. Days of study participation were generally rated as typical of everyday life (*M* = 3.70, *SD* = 1.06, 1 = "not at all" to 5 = "very much").

Daily life assessments were completed by both partners simultaneously, but independently, on separate password protected iPads, using the iDialogPad application (G. Mutz, Cologne, Germany). Partners were instructed not to share their responses with each other during the study period. A fixed time-sampling schedule was used, where participants were instructed to

complete daily life assessments four times per day (at waking, 11:00, 16:00, and 21:00)[3] over seven consecutive days. The waking assessment was self-elicited. The application was programmed to 'beep' at each of the remaining assessment points, although participants were allowed to complete the assessments within a 30 minute grace period before or after the programmed beep.

Saliva samples were also provided parallel to each daily life assessment, using Salivettes (Sarstedt, Germany). Participants were instructed to put a Salivette in their mouth immediately before beginning an electronic assessment on their iPad, and to keep it there until they finished, or until it was saturated with saliva. Saliva samples were then stored in their personal freezer (or fridge, if a freezer was not available) until they were returned to the laboratory for storage at minus 31°C. All cortisol samples were sent to Dresden, Germany, for assay by Clemens Kirschbaum's laboratory. Overall, participants adhered closely to the daily life assessment protocol, providing 89.7% of the requested assessments, and 89.4% of these assessments were provided within 30 minutes of each beep.

3.2.2 Measures

3.2.2.1 Momentary Cortisol

The daily life assessment schedule was designed to capture cortisol's diurnal rhythm across the day (Hoppmann et al., 2018; R. Miller et al., 2016; waking, 11:00, 16:00, and 21:00). Cortisol profiles for each participant were individually inspected during data cleaning, and biologically implausible daily cortisol rhythms were cross-checked with information provided

[3] Cortisol was also measured at 30 minutes post-waking (participants were given a timer to help remind them to complete this assessment exactly 30 minutes after the waking assessment). However, it is not included in the current analyses, because affect ratings were not concurrently measured at this time point.

about medication usage and health conditions that could influence HPA axis activity (Hoppmann et al., 2018). To adjust for skewness, log-transformations were applied to momentary cortisol values (*M* = 1.00, *SD* = 0.12, range = 0.67 - 1.37).

3.2.2.2 Momentary Sadness and Contentment

As part of a larger inventory spanning positive and negative valence, and high and low arousal affective states (Hoppmann & Gerstorf, 2013; Mueller et al., 2020; Tsai et al., 2006; Watson et al., 1988), both spouses in each couple were asked at each measurement point to rate their own current sadness and contentment using a slider-bar from 0 ("not at all") to 100 ("very much"). Intra-individual means were also computed across all momentary assessments of sadness and contentment. On average, spouses rated their current sadness as 11.02 (*SD* = 10.83, range = 0 – 47.21), and their current contentment as 75.72 (*SD* = 13.98, range = 37.71 – 100).

3.2.2.3 Intraindividual Sadness and Contentment Variability (iSD)

Fluctuations in sadness and contentment ratings across the week were captured with the intra-individual standard deviation (iSD; Ram & Gerstorf, 2009). Higher iSD values suggest greater amplitudes of change in sadness or contentment over the week. For the current sample, average sadness iSD was 9.70 (*SD* = 6.83, range = 0 – 32.93), while average contentment iSD was 11.65 (*SD* = 6.19, range = 0 – 33.92).

3.2.2.4 Momentary Perceptions of Shared Feelings

In addition to reporting one's own feelings, each participant was also asked about the degree to which they felt their spouse was currently sharing their feelings with them, at each assessment point, from 0 ("not at all") to 100 ("very much"). On average, participants rated the degree to which their spouse was currently sharing their feelings with them as 58.54 (*SD* = 23.93, range = 4.07 – 100).

3.2.2.5 Covariates

At each repeated daily life assessment, participants were asked whether they had engaged in or consumed nicotine, caffeine, alcohol, medication, food, and physical activity in the last hour; for the purposes of model parsimony, of these variables, only those that were significantly associated with momentary cortisol were retained. On average, participants consumed caffeine prior to 17% of assessments (*SD* = 19%, range = 0 – 75%), ate food prior to 37% of assessments (*SD* = 20%, range = 0 – 82%), and engaged in physical activity prior to 17% of assessments (*SD* = 15%, range – 0 – 64%). In order to facilitate interpretation of partner effects, partner presence was also included as a control variable; on average, partners indicated their spouse was present at 79% of the assessments (*SD* = 19%, range = 19 – 100%). Age, gender, and language of study completion were also included in all models as key individual and couple characteristics.

3.2.3 Analytic Strategy

To account for the non-independent nested data structure, multilevel models were estimated using maximum likelihood in the R package nlme (Pinheiro et al., 2019). Three levels were modelled, with momentary cortisol as the outcome: repeated daily life assessments or ‘moments’, within individuals, within couples (because there was zero variance in momentary cortisol at the day level, differences between days were not included as a separate nesting level). ‘Empty’ multilevel models (where time since waking and time since waking squared were taken into account, in addition to fixed and random intercepts, autocorrelation, and residual error) were used to compute intra-class correlations for momentary cortisol: 56% of variance was at the momentary level, 32% at the person level, and 12% at the couple level.

The Actor Partner Interdependence Model (APIM; Kenny et al., 2006) was adapted to take both one’s own emotional experiences (actor effects) and one’s partner’s emotional

experiences (partner effects) into account. Interactions between one's partner's momentary sadness or contentment and one's own perceptions of their partner sharing their current feelings indexed the moderating role of shared feelings in associations between one's partner's emotional experiences and one's own concurrent cortisol. Simple slope analyses were conducted to probe interactions (Preacher et al., 2006). Full models were adjusted for language of study completion at the between-couple level; as well as age, gender, mean sadness or contentment (actor and partner), sadness or contentment variability (iSD; actor and partner), and mean shared feelings (actor) at the between-person level. Models were also adjusted for within-person caffeine, food, and physical activity in predicting momentary cortisol. Time since waking and time since waking squared were included to account for the diurnal rhythm of cortisol, resulting in the following equations:

Level 1 (Within-Person):

Log Cortisol $s_{ijk} = \beta_{0jk} + \beta_{1jk}$ (Time Since Waking) + β_{2jk} (Time Since Waking Squared)

+ β_{3jk} (Partner Presence) + β_{4jk} (One's Own Sadness/Contentment)

+ β_{5jk} (One's Partner's Sadness/Contentment)

+ β_{6jk} (One's Own Perceptions of Partner Sharing Feelings)

+ β_{7jk} (One's Partner's Sadness/Contentment X One's Own Perceptions of Partner Sharing Feelings)

+ β_{8jk} (Caffeine Consumption) + β_{9jk} (Food Intake) + β_{10jk} (Physical Activity) + r_{ijk}

Level 2 (Between-Person):

$\beta_{0jk} = \gamma_{00k} + \gamma_{001}$ (Age) + γ_{002} (Gender) + γ_{003} (One's Own Mean Sadness/Contentment)

+ γ_{004} (One's Partner's Mean Sadness/Contentment)

$+ \gamma_{005}$ (One's Own Sadness/Contentment iSD)

$+ \gamma_{006}$ (One's Partner's Sadness/Contentment iSD)

$+ \gamma_{007}$ (One's Own Mean Perceptions of Partner Sharing Feelings) $+ u_{0j}$

$\beta_{1jk} = \gamma_{10k} + u_{1j}$ $\beta_{2jk} = \gamma_{20k} + u_{2j}$ $\beta_{3jk} = \gamma_{30k} + u_{3j}$ $\beta_{4jk} = \gamma_{40k} + u_{4j}$

$\beta_{5jk} = \gamma_{50k} + u_{5j}$ $\beta_{6jk} = \gamma_{60k} + u_{6j}$ $\beta_{7jk} = \gamma_{70k} + u_{7j}$

Level 3 (Between-Couple):

$\gamma_{00k} = \delta_{000} + \delta_{001}$ (Language of Study Completion) $+ v_{00k}$

$\gamma_{10k} = \delta_{100} + v_{10k}$ $\gamma_{20k} = \delta_{200} + v_{20k}$ $\gamma_{30k} = \delta_{300} + v_{30k}$ $\gamma_{40k} = \delta_{400} + v_{40k}$

$\gamma_{50k} = \delta_{500} + v_{50k}$ $\gamma_{60k} = \delta_{600} + v_{60k}$ $\gamma_{70k} = \delta_{700} + v_{70k}$

Time since waking was centered at midday (i.e. 8 hours since waking; Adam, 2006; Human et al., 2015), to facilitate interpretation of the intercept as the level of the average individual's cortisol slope at midday. Zero was a meaningful value for caffeine, food, and physical activity and thus remained uncentered. All person and couple level variables were grand-mean centered (with the exception of gender).

3.3 Results

3.3.1 Descriptive Statistics and Intercorrelations

Descriptive statistics (means and standard deviations) and intercorrelations among key study variables are presented in *Table 3.1*. On average, contentment ratings negatively correlated with sadness ratings ($r = –.62$, $p < .001$). Participants who perceived their spouses to be sharing their feelings to a greater extent were also more likely to rate themselves as higher in contentment ($r = .31$, $p < .001$), but there were no associations with sadness ($r = –.06$, $p = .440$).

Greater fluctuations in sadness were associated with higher mean sadness (r = .55, p < .001), and lower mean contentment (r = –.28, p < .001). Greater fluctuations in contentment were associated with lower mean contentment (r = –.32, p < .001), but showed no associations with mean sadness (r = .06, p = .440). Participants who fluctuated a great deal in their sadness ratings were also more likely to fluctuate greatly in their contentment ratings (r = .33, p < .001). Participants who completed the study in Mandarin were more likely to rate their partner as sharing their feelings with them to a greater extent, relative to those who completed the study in English (r = –.26, p < .001). Participants perceived their partners to be sharing their feelings with them to a greater extent when their partner was present, rather than absent (r = .47, p < .001). Older partners and those who completed the study in Mandarin tended to spend more time together on average (r = .30, p < .001; and r = –.30, p < .001, respectively). Participants who completed the study in English were more likely to have greater fluctuations in contentment (r = .24, p = .002), but not sadness (r = .09, p = .246). Momentary cortisol averaged across all time points was not associated with any of the other key study variables.

Multilevel models were used to test primary hypotheses (*Tables 3.2* and *3.3*). Models were built in a stepwise fashion, with the first model (*Model A*) estimating momentary cortisol from partner sadness or contentment, the degree to which individuals rated their partner as sharing their feelings with them, and relevant covariates. The second model (*Model B*) added the interaction between partner sadness or contentment and the degree to which individuals rated their partner as sharing their feelings. Sadness and contentment were considered as predictors in separate models, due to power concerns associated with including multiple two-way interactions in one model. Reductions in deviance were significant from *Model A* to *Model B* for both sadness ($\chi 2$ = 4.57, df = 1, p = .033; *Table 3.3*) and contentment ($\chi 2$ = 6.25, df = 1, p = .012;

Table 3.2), suggesting that the addition of the interaction term improved model fit. Reductions in variance from *Model A* to *Model B* suggested that adding the interaction terms explained an additional 71% of variance for sadness and 87% of variance for contentment. Overall explained variance for *Model B* was approximated using the pseudo R-squared approach (Snijders & Bosker, 2012; sadness *Pseudo* R^2 = 0.03; contentment *Pseudo* R^2 = 0.09).

3.3.2 Associations Between One's Own Momentary Sadness and Contentment with Concurrent Cortisol (Actor Effects)

The degree to which one felt content or sad was associated with momentary cortisol. Participants were more likely to display lower momentary cortisol at times when they were also feeling more content (b = –0.0010, SE = 0.0003, p = .002; *Table 3.2, Model B*) or less sad (b = 0.0007, SE = 0.0003, p = .019; *Table 3.3, Model B*) than their own average contentment or sadness. Hence, my first hypothesis that increases in one's own sadness would be associated with elevations in one's own cortisol, while increases in one's own contentment should be associated with decreases in one's own cortisol, was supported. Momentary cortisol levels were lower when one felt that their partner was sharing their feelings more than usual (b = –0.0006, SE = 0.0002, p < .001). Thus, my second hypothesis was also supported, with greater perceptions of shared feelings associated with lower levels of cortisol.

3.3.3 The Moderating Role of Shared Feelings in Associations Between One's Partner's Momentary Sadness and Contentment and Concurrent Cortisol (Partner Effect)

Associations between one's partner's contentment or sadness and momentary cortisol levels did not emerge as significant main effects (b = –0.0002, SE = 0.0002, p = .568; and b = 0.0001, SE = 0.0003, p = .696, respectively). However, the extent to which one felt their partner was sharing their feelings significantly interacted with one's partner's contentment (b = -

2.6791e-05, *SE* = 1.0724e-05, *p* = .013) and sadness (*b* = 2.8536e-05, *SE* = 1.3376e-05, *p* = .033). Specifically, simple slopes analyses (see *Figure 3.1*) showed that when one felt the spouse was sharing their feelings at 1.5 standard deviations from their average, and when one's partner was also more content than usual, then one's momentary cortisol levels were lower (*b* = –0.0010, *SE* = 0.0004, *p* = .023); if one's partner was instead sadder than usual, then one's momentary cortisol levels were higher (*b* = 0.0010, *SE* = 0.0005, *p* = .048). Hence, my third hypothesis that associations between partner affective states and one's own cortisol secretions would be especially evident when perceptions of shared feelings were higher than usual, was supported. When perceptions of shared feeling were higher than usual, increases in partner sadness were associated with increases in one's own cortisol, and increases in partner contentment were associated with decreases in one's own cortisol.

3.3.4 Additional Analyses: Associations Between Momentary Cortisol and Covariates

Older couples displayed the expected diurnal cortisol profiles, where cortisol declined throughout the day (linear effect), but more slowly towards the end of the day (quadratic effect; *Tables 3.2* and *3.3*). Because time since waking was centered at midday, the intercept indicates that the average cortisol level at midday was 0.77 – 0.78 (*SE* = 0.03, *p* < .001), respectively depending on whether sadness or contentment were modelled as predictors. Contrary to the cortisol literature based on younger and middle-aged adults (Strahler et al., 2017), increased caffeine intake, food intake, and physical activity prior to completing a saliva sample was associated with less elevated cortisol. Partner presence was not associated with momentary cortisol. There were no observed gender differences, but older age was associated with higher momentary cortisol levels. Momentary cortisol was not associated with mean levels of contentment, sadness, or shared feelings. Variability in contentment and sadness (i.e.

contentment and sadness intra-individual standard deviations) were not associated with momentary cortisol levels, and neither was language of study completion.

Table 3.1 Individual means, standard deviations, and intercorrelations of key study variables (N = 84 couples)

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Caffeine intake	0.17	0.19												
2. Food intake	0.37	0.20	.40**											
3. Prior physical activity	0.17	0.15	.31**	.40**										
4. Partner presence	0.79	0.19	.02	.02	-.04									
5. Age	71.08	6.02	-.10	.03	-.01	.30**								
6. Gender	0.50	0.50	-.03	.09	-.02	.03	-.20*							
7. Language	0.70	0.46	.39**	.09	.37**	-.30**	-.29**	.00						
8. Mean sadness	11.02	10.83	-.12	.11	.01	.01	-.04	.17*	-.12					
9. Mean contentment	75.72	13.98	.06	-.09	-.00	.10	.07	-.11	.08	-.62**				
10. Mean sharing feelings	58.54	23.93	-.14	-.06	-.13	.47**	.07	.01	-.26**	-.06	.31**			
11. Sadness iSD	9.70	6.83	.03	.05	.20**	.04	.02	.07	.09	.55**	-.28**	.04		
12. Contentment iSD	11.65	6.19	.14	.13	.23**	-.03	-.02	-.04	.24**	.06	-.32**	-.21**	.33**	
13. Cortisol ($\log10_{nmol/L}$)	0.90	0.13	-.00	.03	.02	-.00	.10	-.06	.16*	.05	-.02	-.04	.08	-.03

Note. Gender coded as 0 = man, 1 = woman. Language of study completion coded as 0 = Mandarin, 1 = English. Caffeine intake and prior physical activity coded as 0 = “did not engage in this behavior in the previous hour”, 1 = “did engage in this behavior in the previous hour”. Partner presence coded as 0 = “partner not present”, 1 = “partner present”. Momentary contentment and sadness aggregated and scored from 0 = “not at all” to 100 = “very much”). * $p < .05$, ** $p < .01$.

Table 3.2 Multilevel models predicting momentary salivary cortisol (log10nmol/L; dependent variable) from momentary contentment, partner sharing feelings, and covariates using maximum likelihood estimation (N = 4132 observations from 84 couples)

	Model A	Model B
Fixed Effects	*b* (*SE*)	*b* (*SE*)
Intercept	0.7827 (0.0255)**	0.7823 (0.0256)**
Level 1 (Within Person)		
Time since waking	-1.8082e-05 (7.0836e-07)**	-1.8112e-05 (7.0843e-07)**
Time since waking squared	7.4821e-11 (1.3330e-11)**	7.5281e-11 (1.3306e-11)**
Caffeine intake	-0.0218 (0.0106)*	-0.0221 (0.0106)*
Food intake	-0.0163 (0.0084)	-0.0164 (0.0084)*
Prior physical activity	-0.0199 (0.0095)*	-0.0198 (0.0095)*
Partner presence	0.0076 (0.0099)	0.0085 (0.0099)
Contentment (actor)	-0.0010 (0.0003)**	-0.0010 (0.0003)**
Contentment (partner)	-0.0001 (0.0003)	-0.0002 (0.0003)
Partner sharing feelings (actor)	-0.0006 (0.0002)**	-0.0006 (0.0002)**
Contentment (partner) x Partner sharing feelings (actor)		-2.6791e-05 (1.0724e-05)*
Level 2 (Between Person)		
Age	0.0040 (0.0018)*	0.0040 (0.0018)*
Gender	-0.0143 (0.0190)	-0.0139 (0.0190)
Mean contentment (actor)	-0.0001 (0.0009)	-0.0001 (0.0009)
Mean contentment (partner)	0.0005 (0.0008)	0.0005 (0.0008)
Contentment variability iSD (actor)	-0.0007 (0.0018)	-0.0007 (0.0018)
Contentment variability iSD (partner)	0.0015 (0.0020)	0.0016 (0.0020)
Mean partner sharing feelings (actor)	-0.0002 (0.0005)	-0.0002 (0.0005)
Level 3 (Between Couple)		
Language of study completion	0.0404 (0.0269)	0.0406 (0.0269)

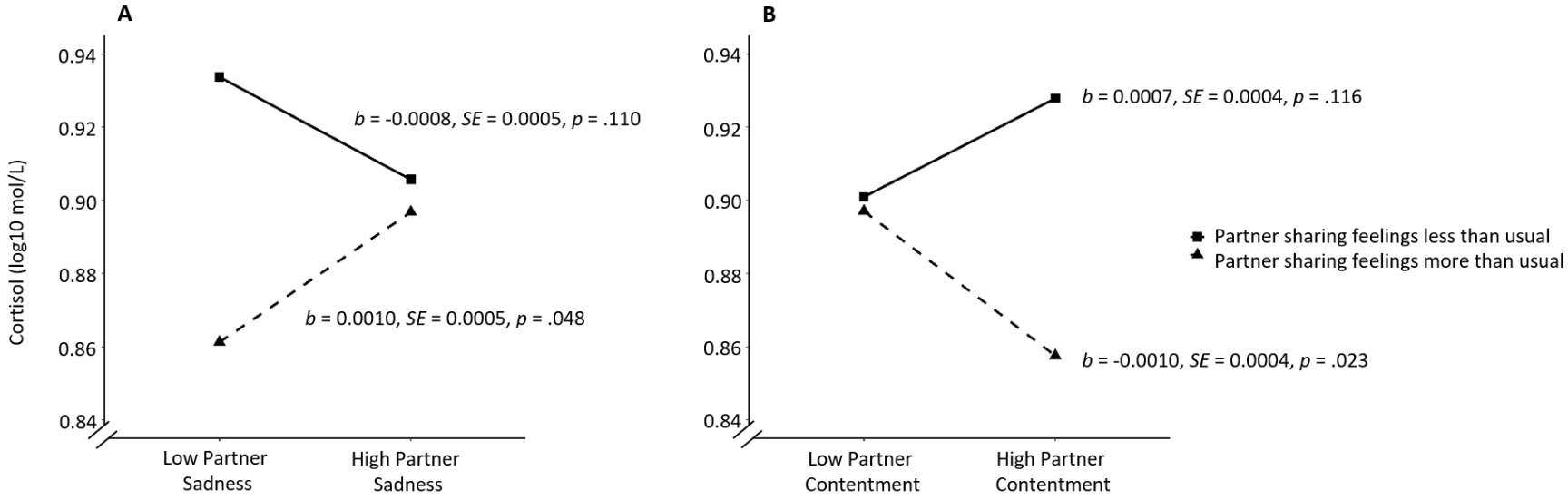
Note. Gender coded as 0 = man, 1 = woman. Language of study completion coded as 0 = Mandarin, 1 = English. Caffeine intake, food intake, and prior physical activity coded as 0 = “did not engage in this behavior in the previous hour”, 1 = “did engage in this behavior in the previous hour”. Partner presence coded as 0 = “partner not present”, 1 = “partner present”. Momentary contentment and partner sharing feelings scored from 0 = “not at all” to 100 = “very much”. * $p < .05$, ** $p < .01$.

Table 3.3 Multilevel models predicting momentary salivary cortisol ($log10_{nmol/L}$; dependent variable) from momentary sadness, partner sharing feelings, and covariates using maximum likelihood estimation (N = 4132 observations from 84 couples)

	Model A	Model B
Fixed Effects	*b* (*SE*)	*b* (*SE*)
Intercept	0.7731 (0.0255)**	0.7726 (0.0255)**
Level 1 (Within Person)		
Time since waking	-1.8205e-05 (7.0834e-07)**	-1.8191e-05 (7.0847e-07)**
Time since waking squared	7.5457e-11 (1.3339e-11)**	7.5311e-11 (1.3329e-11)**
Caffeine intake	-0.0226 (0.0106)*	-0.0225 (0.0106)*
Food intake	-0.0158 (0.0084)	-0.0158 (0.0084)
Prior physical activity	-0.0206 (0.0095)*	-0.0206 (0.0095)*
Partner presence	0.0073 (0.0099)	0.0086 (0.0099)
Sadness (actor)	0.0008 (0.0003)*	0.0007 (0.0003)*
Sadness (partner)	0.0001 (0.0003)	0.0001 (0.0003)
Partner sharing feelings (actor)	-0.0006 (0.0002)**	-0.0006 (0.0002)**
Sadness (partner) x Partner sharing feelings (actor)		2.8536e-05 (1.3376e-05)*
Level 2 (Between Person)		
Age	0.0041 (0.0018)*	0.0041 (0.0018)*
Gender	-0.0081 (0.0197)	-0.0080 (0.0197)
Mean sadness (actor)	-0.0001 (0.0012)	-0.0001 (0.0012)
Mean sadness (partner)	0.0012 (0.0012)	0.0012 (0.0012)
Sadness variability iSD (actor)	0.0014 (0.0018)	0.0014 (0.0018)
Sadness variability iSD (partner)	-0.0009 (0.0018)	-0.0008 (0.0018)
Mean partner sharing feelings (actor)	3.4353e-05 (0.0005)	3.3713e-05 (0.0005)
Level 3 (Between Couple)		
Language of study completion	0.0544 (0.0264)*	0.0543 (0.0264)*

Note. Gender coded as 0 = man, 1 = woman. Language of study completion coded as 0 = Mandarin, 1 = English. Caffeine intake, food intake, and prior physical activity coded as 0 = “did not engage in this behavior in the previous hour”, 1 = “did engage in this behavior in the previous hour”. Partner presence coded as 0 = “partner not present”, 1 = “partner present”. Momentary sadness and partner sharing feelings scored from 0 = “not at all” to 100 = “very much”. * $p < .05$, ** $p < .01$.

Figure 3.1 Illustration of two-way interaction effects (Model B)



Note. Although all depicted variables were considered continuous, they are shown at high and low levels ($M \pm 1.5\ SD$) for illustrative purposes. The extent to which one's partner is sharing their feelings is differentially associated with one's own salivary cortisol, depending on whether their partner is sad or content. When partners were sharing their feelings more than usual, partner sadness was positively associated with one's own cortisol (Panel A), while partner contentment was negatively associated with one's own salivary cortisol (Panel B).

3.4 Discussion

The purpose of this study was to examine within-person associations between salivary cortisol and two discrete emotional experiences that are especially relevant in older adulthood: sadness and contentment. Recognizing that emotional experiences are often concurrently linked within couples, I examined not only one's own sadness and contentment, but also one's partner's sadness and contentment, as well as perceptions of shared feelings as a key moderator of time-varying associations with salivary cortisol. Findings were consistent with my expectations in that increases in one's own sadness were associated with increases in salivary cortisol, whereas increases in one's own contentment were associated with decreases in salivary cortisol. My expectations that one's partner's sadness and contentment would show similar associations with one's own cortisol, but only if one's partner was sharing their feelings to a greater extent, were also supported. Findings are discussed in the context of the health psychological and aging literatures.

3.4.1 Associations Between One's Own Momentary Sadness and Contentment with Concurrent Cortisol

I found that occasions when participants experienced more sadness than their own average sadness level, cortisol was up. The opposite association emerged for contentment, where increases in contentment, relative to one's own average level of contentment, were associated with decreases in one's own cortisol level. By focusing on these discrete low arousal emotions, I extend previous literature showing broadly that negative emotions are generally associated with cortisol reductions in older adults (Adam et al., 2006; Piazza et al., 2013; Smyth et al., 1998), while positive emotional experiences are generally associated with cortisol increases (Nater et al., 2010; Smyth et al., 1998; Steptoe & Wardle, 2005; Steptoe et al., 2007; Steptoe et al., 2005).

These momentary cortisol increases and decreases associated with higher sadness and contentment, respectively, are likely indicative of flexible responding to changing daily life circumstances (Fleeson, 2004; Levy-Gigi, et al., 2016), especially since cortisol diurnal rhythms showed the typical changes characteristic of healthy samples. These findings are important, because it is plausible that if experiences of sadness are frequent or prolonged, they may eventually accumulate into dysregulated diurnal cortisol profiles. For example, previous findings have shown that depressive symptoms are associated with atypical diurnal cortisol slopes in older adults (Balardin et al., 2010; Fiocco et al., 2006). Hence, momentary increases and decreases in cortisol are not necessarily 'good' or 'bad' in and of themselves, but perhaps reflective of maintained physiological responding – however, they could become health-relevant down the road.

3.4.2 The Moderating Role of Shared Feelings in Associations Between One's Partner's Momentary Sadness and Contentment with Concurrent Cortisol

While having a spouse that shares their feelings when they are content was linked with reductions in cortisol, occasions when a spouse shared their emotions when they were sad was linked with increases in cortisol. These findings are in line with literature showing that emotions correspond between spouses (Larson & Almeida, 1999), and extend previous findings that the emotions of one's spouse can be reflected in one's own cortisol levels (Slatcher et al., 2011) to older adult couples and discrete low arousal emotions. While being vulnerable to the negative emotional experiences of one's partner may represent a physiological cost in the short term, perhaps it allows spouses to be aware of each other's problems and engage in dyadic coping strategies. For example, conflict avoidance may be an effective emotion regulation strategy in the short term, but can also limit relationship functioning in the long term (DeLongis & Zwicker,

2017; Gottman & Levenson, 2002). Although previous literature has mainly focused on the transmission of negative emotions, having positive emotional experiences (such as contentment) shared within couples may also represent a mechanism by which spouses are able to provide protective resources in the face age-related challenges. Indeed, being 'let in' has generally been linked with better health and relationship outcomes in long-term marriages (Driver & Gottman, 2004; Haase et al., 2016). Hence, perceptions of shared feelings represent a potential pathway through which spouses can emotionally and physiologically influence each other.

3.4.3 Limitations and Future Directions

Emotional experiences and salivary cortisol were concurrently assessed several times per day, over the span of a week, from both members of older adult couples. This approach allowed me to capture within-person changes in the way emotions and cortisol ebbed and flowed together over time, not only in the individual, but while taking the partner into account. The recruitment for and procedures involved in such study protocols can be challenging, but provide a richer picture of functioning in the daily lives of older adult couples. However, the presented findings must be interpreted in light of several limitations.

Generally, the cortisol diurnal rhythm is more likely to be compromised in older age, as evidenced by older adults generally showing increased overall cortisol secretion, attenuated slopes, and a steeper cortisol awakening response, relative to younger adults (Nater et al., 2013). Further, adults aged 60 and over who show non-normative diurnal cortisol profiles are at greater risk for inflammation concurrently and functional limitations 10 years later (Piazza et al., 2018). The current sample of older adult couples overall showed typical patterns of diurnal cortisol patterns, had generally high relationship satisfaction, and were community-dwelling. Hence, it is an open question if a less healthy and well-functioning sample of older adults would show the

same or dissimilar patterns of cortisol responding to emotional experiences. Future research would be well-informed by examining such associations in populations that are facing significant age-related challenges, specifically addressing how relationship-relevant behaviors, such as sharing emotions, may be harnessed to improve health and relationship trajectories in older age.

The relationship between emotions and health is likely bidirectional, and as the data reported in the current study is correlational, it does not establish causality. For example, frequent experiences of negative affect are likely detrimental for health, while facing a challenging health condition in turn likely elicits greater negative affect (Kunzmann et al., 2019). Positive emotions, on the other hand, may be cultivated to prevent, but also dampen the detrimental effects of health challenges (including increases in negative affect; Fredrickson, 2001). Hence, it would be interesting to prospectively track emotional experiences, cortisol levels, and ultimate health outcomes to further understand directionality, and also potential points of intervention. Based on current and previous findings that the emotional experiences and physiological health of the spouse also matter for the individual, the dyadic context of these associations should be taken seriously.

Lastly, while the current study asked participants to report on their perceptions of the degree to which their spouse was sharing their feelings with them, it was not specifically asked whether their spouse was sharing their sadness or contentment. Hence, it is an assumption that if one is feeling more sad or content than their own average level of that respective emotion, then it is in fact this specific state that they are sharing with their spouse. Future studies may consider increasing measurement precision by asking which emotions are being shared specifically, although this must be balanced by considerations of feasibility and participant burden that comes

with asking additional questions in repeated daily life assessments (Gerstorf et al., 2014; Hoppmann & Riediger, 2009; Scollon et al., 2009).

3.4.4 Conclusions

Overall, this study extends the existing literature on affect-cortisol linkages in older age by providing initial evidence that within-person decreases in sadness and increases in contentment are associated with reductions in salivary cortisol in the everyday lives of community-dwelling older adult couples. These findings also suggest that not only do one's own emotional experiences play a role in momentary cortisol changes, but those of the partner do as well, if they are sharing their emotions. Hence, although one's partner can represent an important social resource, there are also time-varying costs and opportunities associated with sharing emotional experiences within a marital relationship. Future research would benefit from taking a longitudinal approach to investigate if and how not only one's own, but also one's partner's, emotional experiences shape longer term physical and mental health outcomes. This was the focus of Chapter 4.

Chapter 4: Dyadic Associations Between Everyday Affect Variability with Levels of and Changes in Cardiovascular Risk and Environmental Mastery

4.1 Introduction

Emotional experiences have well-established connections to physical and mental health (Cohen & Pressman, 2006; Fredrickson, 2000, 2001; Kiecolt-Glaser et al., 2002; Kunzmann et al., 2019). Importantly, emotional states are dynamic, and everyday changes within a short span of time have been shown to be independently associated with adverse physical and mental health outcomes (Ong & Ram, 2017). Everyday emotional dynamics are also interpersonal, with social partners shaping emotional experiences through a variety of processes (see Butler, 2015 for a review). This may be particularly true in older adulthood when meaningful emotional experiences and close social relationships are prioritized due to perceptions of limited time left in life (Socio-emotional Selectivity Theory; Carstensen et al., 1999; Carstensen et al., 2003). Importantly, older adulthood is a developmental phase marked by age-related increases in vulnerability, such as heightened cardiovascular risk (Franklin et al., 1997; Kannel & Gordon, 1978; Knight et al., 2001) and reductions in mastery of personal circumstances (Robinson & Lachman, 2017; Ryff, 2008). The goal of the current study was to prospectively investigate concurrent and longitudinal associations between short-term fluctuations in emotional experiences and cardiovascular risk as well as environmental mastery. In doing so, I also strove to account for dyadic linkages in the underlying processes, using data from a sample of older couples.

4.1.1 Dynamic Emotional Experiences

As individuals move through different situations in everyday life, their corresponding emotional experiences also change. The degree to which one's affective state deviates from how one usually feels (i.e. their average level of a given affective state across different daily life situations) is defined as affect variability (Ong & Ram, 2017; Ram & Gerstorf, 2009). Conceptually speaking, affect variability captures fluctuations in affective states in response to naturally occurring daily life situations, such as hearing a touching news segment or being cut off by another car on the highway. Although there are many ways of operationalizing intra-individual affect variability (Ebner-Premier et al., 2007; Ram & Gerstorf, 2009), the most intuitive and broadly used index is the intra-individual standard deviation (iSD; Ram & Gerstorf, 2009), where a standard deviation across all measurement points is calculated for each individual, and a greater iSD is interpreted as characteristically deviating from one's mean to a greater extent. Importantly, measures of variability, such as the iSD, are not independent from the intra-individual mean. A common approach to account for this dependency is to include the mean as an additional predictor (e.g. Jones et al., 2020; Koval et al., 2013), which is conceptually appealing because mean levels of emotional experiences in and of themselves are associated with physical and mental health.

Greater affect variability is generally associated with worse physical and mental health (Ong & Ram, 2017). Little is known about the time-ordered nature of this association. Conceptually, it would be reasonable to assume that health problems have the capacity to disrupt affective experiences, thus resulting in high affect variability, but also that frequent and large fluctuations in affective states increase physical and mental health risks over time. The current chapter builds on empirical evidence suggesting that greater daily affect reactivity to stressors is

related to worse physical and mental health a decade later (Charles et al., 2013; Piazza et al., 2013). Specifically, I examined whether high affect variability in the daily lives of older adults is associated with concurrent as well as subsequent changes in physical and mental health over a span of three years.

4.1.2 Aging and Emotional Experiences in a Social Context

Although aging is characterized by declines in physical health and cognitive functioning, emotional well-being is relatively well-maintained, and sometimes even improves, compared to young and middle adulthood (Carstensen et al., 2000). Age-related improvements in emotional well-being are often explained by Socioemotional Selectivity Theory, which posits that perceptions of limited time left leads to motivational shifts towards emotionally meaningful social interactions (Carstensen et al., 2003; Carstensen et al., 1999). In line with this prominent aging model, affect variability is generally reduced in older age, relative to earlier life phases, likely due to improved emotion regulation abilities and increased selectivity into less emotionally challenging daily life situations (Carstensen & Gross, 1997; Röcke & Brose, 2013). Importantly, the Strength and Vulnerability Integration (SAVI) model suggests that despite increased emotion regulation capacities and avoidance of stressful situations, older adults are particularly vulnerable to stress when such efforts fail, compared to younger adults (Charles, 2010). Hence, it is reasonable to expect that older adults are vulnerable to the correlates and consequences of higher affect variability, culminating into increased physical and mental health risks over time.

Emotional experiences are often interpersonal (Butler, 2015), and marriage represents a key social context in which emotions unfold and are regulated in older age (Hoppmann & Gerstorf, 2009, 2016). Marital partners often share in each other's affective states in daily life (e.g. Larson & Almeida, 1999; Michalowski et al., 2018), especially when spouses are jointly

involved in problem-solving (Berg et al., 2011; Hicks & Diamond, 2008; Monin & Schulz, 2009), and longitudinally (Hoppmann et al., 2011). Hence, dynamic links between spousal emotional experiences are found using both daily life assessments and longitudinal designs, suggesting that these interrelations exist across a range of time scales. Further, purposefully sharing emotions in long-term marriages may be related to better health and relationship functioning (Driver & Gottman, 2004; Haase et al., 2016). Taken together, while individual emotional experiences are often targeted for their association with health, it is reasonable to expect that the emotional experiences of one's spouse are also closely linked with one's own health, and that sharing emotions within the spousal relationship may confer health benefits.

4.1.3 Cardiovascular Risk and Environmental Mastery in Older Adulthood

The current study focuses on two indicators of physical and mental health that are especially relevant to older adults: cardiovascular risk and perceived mastery over daily life management. Relative to younger and middle-aged adults, older adults are more vulnerable to increases in cardiovascular risk (Franklin et al., 1997; Kannel & Gordon, 1978; Knight et al., 2001) and reductions in mastery (Robinson & Lachman, 2017; Ryff, 2008). Cardiovascular risk is captured through pulse pressure (an objectively measured predictor of cardiovascular disease; Franklin et al., 1997), while environmental mastery is conceptualized as a subjective cognitive evaluation (Ryff, 2008).

Pulse pressure captures pulsatile blood pressure, and is operationalized as the difference between systolic and diastolic blood pressure, with heightened pulse pressure in older adulthood indicating greater artery calcification and coronary heart disease risk (Franklin et al., 1997). Emotional experiences are closely intertwined with cardiovascular health in older age (Shiota & Neufeld, 2014), with negative emotions corresponding with blood pressure increases in response

to stressor tasks in the laboratory (Uchino et al., 2010), and positive emotions accelerating cardiovascular recovery elicited by negative emotions (Fredrickson & Levenson, 1998). In daily life settings, high levels of positive and negative affect variability have been linked with a variety of cardiovascular risk indicators, including increased systemic inflammation (Jones et el., 2020) and lower heart rate variability (Koval et al., 2013). Based on the existing body of literature, higher positive and negative affect variability were expected to be associated with higher initial pulse pressure and steeper increases in pulse pressure over time.

The mental health component targeted in this study was environmental mastery, which uniquely captures the perceived match between one's needs and capabilities, and the demands of one's environment (Ryff, 1989, 2008). This construct is distinct from but conceptually related to perceived control (Robinson & Lachman, 2017) and self-efficacy (Bandura, 1997). The conceptual space captured by environmental mastery is the maintenance of control over daily life management. Linkages between control and health outcomes are likely reciprocal (Robinson & Lachman, 2017), but generally speaking, greater perceptions of control in older adulthood are associated with better cognitive functioning, physical health, and emotional well-being (Gerstorf et al., 2011; Kunzmann et al., 2002; Lachman, 2006). In daily life settings, higher levels of mastery have been associated with lower physiological reactivity to work stressors and lower emotional reactivity to network stressors (Neupert et al., 2007), suggesting that perceptions of mastery are associated with emotional responding in daily life. Hence, it was expected that higher positive and negative affect variability would be associated with lower initial environmental mastery and steeper decreases in environmental mastery over time.

4.1.4 The Current Study

The primary aim of the current chapter was to examine not only concurrent associations between individual and spousal affect variability, and environmental mastery and pulse pressure, but also prospectively examine changes in these key indicators over three years. It was expected that greater positive and negative affect variability, whether it is one's own or one's spouse's, would be associated with: 1) higher initial levels of pulse pressure, as well as increases in pulse pressure over time; and 2) lower initial levels of environmental mastery, and decreases in environmental mastery over time. On the other hand, greater mean levels of positive affect, lower mean levels of negative affect, and greater perceptions of spousal shared feelings (i.e. being emotionally 'let in') were expected to be associated with: 1) lower initial levels of and decreases in pulse pressure; and 2) higher initial levels of and increases in environmental mastery. Many other factors may be associated with my mental and physical health constructs of interest (Knight et al., 2001; Robinson & Lachman, 2017). Based on existing literature, age and cultural heritage were included as key covariates. Gender differences were examined by modelling initial levels and changes of health as separate, but correlated, for husbands and wives (Peugh et al., 2013).

4.2 Methods

4.2.1 Participants and Procedures

The current research examined data provided by 119 heterosexual older adult couples (*M* age = 70.97 years, *SD* = 6.01, range = 60 – 87; *M* marriage duration = 40.91 years, *SD* = 13.0, range = 0.5 – 64.0; 59.5% Caucasian, 34.6% East Asian; 66.0% with at least some college education), who were all community-dwelling and living in the Greater Vancouver Area, Canada. The couples were recruited for a larger study on spousal health dynamics in older age

(see Ashe et al., 2019; Michalowski et al., 2020; Pauly, Keller, et al., 2019; Pauly, Michalowski, et al., 2019), through print and online advertisements in the community and existing subject pools. Eligibility criteria required both spouses to: participate at the same time (only in Year 1; one or both spouses were able to participate in the yearly follow up assessments); have written and oral fluency in English, Cantonese, or Mandarin; be aged at least 60 years; be able to read newspaper sized print and hear an alarm; not have any medical conditions that were neurodegenerative or that impaired physical activity (for study purposes not related to the current research).

Participants were asked to complete a battery of self-reported questionnaires and health measurements (e.g. blood pressure) at a laboratory visit, and then provided electronic repeated daily life assessments 4 times daily (at wake up, 11am, 4pm, and 9pm) for one week in Year 1. They were invited to return for annual follow-up assessments at Years 2 and 3 (although repeated daily life assessments were only completed in Year 1). Each spouse received $100 CAD as reimbursement in Year 1, and $50 CAD for each annual follow-up assessment they participated in. Spouses were able to participate in follow-up assessments even if their spouse did not. All participants provided informed consent, and ethics approval was granted by the clinical research ethics board of the University of British Columbia.

The larger study recruited a total of 129 older adult couples, of which 9 couples did not complete the repeated daily life assessments and 1 couple had language difficulties. Hence, the final sample retained in the current research is 119 older adult couples. Of the 119 couples (238 individuals) whose data is included at Year 1, 178 individuals returned to participate in the second annual assessment (Year 2; M = 12.91 months after initial assessment, SD = 1.57, range = 11.47 – 20.63), and 174 individuals for the third annual assessment (Year 3; M = 24.56 months

after initial assessment, *SD* = 1.09, range = 22.37 – 30.62). There were 40 individuals who only participated in Year 1, but did not complete any of the longitudinal follow-up assessments (i.e. Years 2 or 3), meaning that there were 198 individuals who did complete at least one follow-up assessment. Participants who did not complete at least one follow-up assessment did not differ from those who returned in age (t = 0.02, p = .983), subjective health (t = 0.13, p = .898), pulse pressure (t = -1.60, p = .116), environmental mastery (t = 0.46, p = .648), positive affect variability (t = 0.09, p = .930), negative affect variability (t = 0.33, p = .743), mean positive affect (t = 0.39, p = .698), mean negative affect (t = 1.01, p = .319), mean perceptions of shared feelings (t = -0.02, p = .984), or language of study completion (t = 1.06, p = .295).

4.2.2 Measures

4.2.2.1 Positive and Negative Affect Variability

Current affect was reported at each daily life assessment in Year 1, using a slider-bar ranging from 0 (“not at all”) to 100 (“very much”). Affect items were selected to include positive and negative valence, and high and low arousal (Hoppmann & Gerstorf, 2013; Mueller et al., 2020; Tsai et al., 2006; Watson et al., 1988). Positive affect items included *happy*, *calm*, *alert*, *relaxed*, *content*, *enthusiastic*, *interested*, *excited*, and *satisfied*; while negative affect items included *sad*, *overwhelmed*, *irritated*, *annoyed*, *lonely*, *anxious*, *tired*, and *nervous*. Positive and negative affect composites were created by averaging across the respective items at each time point, for each individual. Positive and negative affect variability was operationalized as the intra-individual standard deviation (iSD; Ram & Gerstorf, 2009), where a higher iSD indicates a greater amplitude of change across daily life assessment points. Mean positive affect variability was 8.70 (*SD* = 4.08, range = 0.45 – 30.36), and mean negative affect variability was 7.94 (*SD* = 4.15, range = 0.47 – 21.70).

4.2.2.2 Mean Positive and Negative Affect

Intra-individual means were computed across all daily life assessments of positive and negative affect. The sample average for mean positive affect was 69.46 (*SD* = 12.86, range = 25.40 – 99.88) and mean negative affect was 16.73 (*SD* = 12.05, range = 0.32 – 53.98).

4.2.2.3 Mean Perceptions of Partner Sharing Feelings

At each daily life assessment in Year 1, each spouse was asked "To what extent is your partner currently sharing his or her feelings with you?" from 0 ("not at all") to 100 ("very much") on a slider-bar. The average extent to which spouses rated their partner as sharing their feelings with them was 70.71 (*SD* = 14.85, range = 23.33 – 100).

4.2.2.4 Pulse Pressure

At every annual assessment (i.e. Years 1, 2, and 3), participants were asked to provide blood pressure measurements in the laboratory, as part of their in-person interview. After completing a battery of self-report questionnaires, spouses were individually taken into a separate room, where they were seated with their left arm resting on a table beside them. A cuff was fitted and secured around the participant's upper arm, after which the research assistant left the room, and an oscillometric device (BpTru Medical Devices Ltd. VSM Medtech) automatically took a total of 6 systolic and diastolic readings, spaced two minutes apart. An average was automatically calculated by the machine for systolic and diastolic blood pressure at the end of the readings. The procedure was designed to minimize any effects that might artificially raise blood pressure readings, such as white-coat effects, and produce comparable data to those obtained from gold standard methods, such as 24-hour ambulatory monitoring (Beckett & Godwin, 2005; Myers & Valdivieso, 2003). Pulse pressure was computed as the difference between systolic and diastolic blood pressure, where higher pulse pressure is

indicative of increased risk for coronary heart disease in middle-aged and older adults (Franklin et al., 1999). Pulse pressure greater than or equal to 60 mmHg is considered high in hypertensive older adults (Williams et al., 2018). Mean pulse pressure was 50.21 mmHg (*SD* = 11.52, range = 32.00 – 96.00; 30.8% >= 60 mmHg) at Year 1, 52.28 mmHg (*SD* = 12.23, range = 26.00 – 97.00; 30.8% >= 60 mmHg) at Year 2, and 52.77 mmHg (*SD* = 13.98, range = 25.00 – 108.00; 36.0% >= 60 mmHg) at Year 3.

4.2.2.5 Environmental Mastery

Participants also completed a reduced form of the Scales of Psychological Well-Being (Ryff, 1989) at every annual assessment. The 3-item version of the Environmental Mastery scale is focused on in the current research, due to its relatively lower conceptual overlap with emotional well-being, and emphasis on keeping up with the demands of daily living, which becomes increasingly relevant for independence in older age. The following three items were averaged to create a composite score for each participant: "In general, I feel I am in charge of the situation in which I live," "The demands of everyday life often get me down," (reverse-coded) and "I am quite good at managing the many responsibilities of my daily life," which were rated on a 5-point scale from 1 ("strongly disagree") to 5 ("strongly agree"). On average, participants' mean environmental mastery was 3.99 (*SD* = 0.55, range = 2.00 – 5.00; alpha = .62) at Year 1, 3.92 (*SD* = 0.55, range = 2.33 – 5.00; alpha = .66) at Year 2, and 4.04 (*SD* = 0.55, range = 2.33 – 5.00; alpha = .65) at Year 3.

4.2.2.6 Covariates

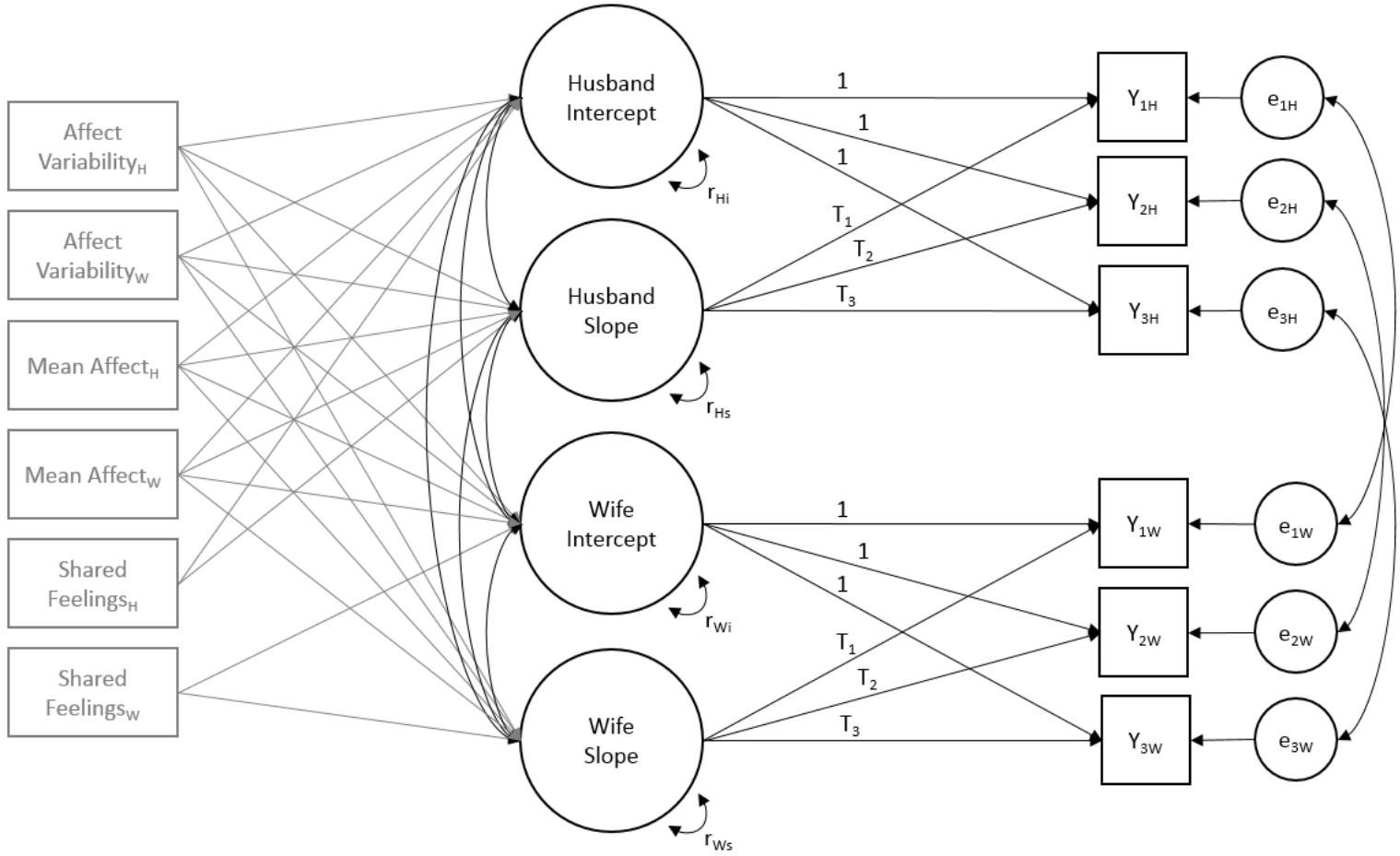
Age and language of study completion (where 0 = Mandarin and 1 = English) were included as covariates in models predicting initial levels of and changes in pulse pressure and environmental mastery.

4.2.3 Analytic Strategy

Baseline levels of and longitudinal changes in environmental mastery and pulse pressure were examined using dyadic latent growth curve structural equation models in Mplus version 8 (Muthén & Muthén, 2017), in line with statistical recommendations provided by Peugh et al. (2013). Models specified intercepts and slopes separately for wives and husbands that were allowed to correlate with each other (see *Figure 4.1*). The intercept represents initial levels of the outcome of interest (i.e. environmental mastery, pulse pressure) at Year 1, and the slope represents linear changes in the outcome over the three annual assessments. Observed factor loadings on to the latent intercepts were fixed (1, 1, 1), while the means and variances of the latent factors were freely estimated. Intercept-slope covariances and covariances between outcome residuals for husbands and wives were also freely estimated, in recognition of the interdependent data structure. Observed factor loadings on the latent slopes were fixed (1, 2, 3), but because length of time between annual assessments varied between individual participants, slope loadings were fixed individually using the TSCORES option. Affect variability, mean affect, and shared feelings at Year 1, from the perspective of both husbands and wives, were added to the generic dyadic growth curve model (see *Figure 4.1*), as key predictors of the initial levels of and changes in pulse pressure and environmental mastery. Positive and negative affect were considered in separate models, to maximize power. Age and language of study completion were included as control variables in each model. Incomplete data was accounted for by maximum likelihood estimation with robust standard errors. A consequence of individually fixing slope loadings to account for inter-individual differences in time between annual assessments is that overall model fit indices are not available, because the outcome variance is different across participants. To evaluate model fit in lieu of overall model fit indices, chi-square

difference tests based on log-likelihood values and scaling correction factors for full and nested comparison models were used.

Figure 4.1 Generic correlated growth curve model including key study variables.



Note. Husbands and wives are allowed to have separate, but related, initial levels of (i.e. intercepts) and changes in (i.e. slopes) pulse pressure and environmental mastery over three annual assessments. Baseline affect variability, mean affect, and perceptions of shared feelings are specified as key predictors of slopes and intercepts. Age and language of study completion are controlled for in the model, but not shown in the figure.

4.3 Results

4.3.1 Descriptive Statistics and Intercorrelations

Table 4.1 shows means and standard deviations for wives and husbands separately, and intercorrelations between key study variables aggregated across husbands and wives. Paired sample t-tests were conducted to examine gender differences been wives and husbands. Notably, husbands and wives showed comparable levels of positive affect variability (t = 1.61, p = .110), but husbands had higher positive affect on average (t = –2.39, p = .019). On the other hand, wives had higher negative affect variability (t = 2.06, p = .042) and higher average levels of negative affect (t = 3.73, p < .001), relative to their husbands. Husbands tended to see their spouse as sharing their feelings to a greater extent (t = –2.47, p = .015), compared to wives. Husbands were also older than wives, on average (t = –6.36, p < .001). There were no differences in language of study completion by design, as each couple completed the study in the same language, together. No gender differences emerged for pulse pressure at any of the time points (Year 1 t = 1.90, p = .059; Year 2 t = 1.44, p = .153; Year 3 t = 0.69, p = .492), nor for environmental mastery (Year 1 t = –0.99, p = .320; Year 2 t = 0.15, p = .879; Year 3 t = –0.16, p = .871).

Intercorrelations revealed that individuals higher in negative affect variability also tended to be higher in positive affect variability (r = 0.62, p < .001), have higher mean negative affect (r = 0.43, p < .001), lower mean positive affect (r = –0.24, p < .001), and perceive their spouse as sharing their feelings to a lesser extent with them (r = –0.17, p = .009). Higher positive affect variability was also associated with lower mean positive affect (r = –0.19, p = .003), but not with mean negative affect (r = 0.05, p = .413) or perceptions about the degree to which one's spouse is sharing their feelings (r = –0.04, p = .516). Participants who completed the study in

English were more likely to show higher positive affect variability (r = .22, p < .001), higher negative affect variability (r = .19, p = .003), and higher mean positive affect (r = 0.29, p < .001), but no differences in mean negative affect (r = –.10, p = .113), compared to those who completed the study in Mandarin. Study completion in English was also associated with greater perceptions of shared feelings by one's spouse (r = .31, p < .001), and higher environmental mastery in Year 3 (r = .24, p = .002). Older participants were more likely to complete the study in Mandarin (r = –.30, p < .001) and to have higher pulse pressure at baseline (r = .17, p = .009).

Higher negative affect variability in Year 1 was associated with lower environmental mastery in Year 1 (r = –.31, p < .001), Year 2 (r = –.23, p = .002), and Year 3 (r = –.16, p = .041), as was higher mean negative affect at each annual assessment (Year 1 r = –.41, p < .001; Year 2 r = –.35, p < .001; Year 3 r = –.39, p < .001). Positive affect variability in Year 1 was not significantly correlated with environmental mastery at any annual assessment (Year 1 r = –.08, p = .193; Year 2 r = –.04, p = .581; Year 3 r = .03, p = .703). Higher mean positive affect in Year 1 was related to higher environmental mastery at every annual assessment (Year 1 r = .44, p < .001; Year 2 r = .30, p < .001; Year 3 r = .39, p < .001). Perceiving that one's spouse shared their feelings to a greater extent in Year 1 was associated with higher environmental mastery concurrently (r = .36, p < .001), and at one (r = .20, p = .007) and two years later (r = .27, p < .001).

Pulse pressure at every time point was unrelated to mean levels of and variability in positive and negative affect, as well as perceptions of one’s partner sharing their feelings (see *Table 4.1*). Pulse pressure measurements at each time point were positively associated with pulse pressure measurements at every other time point (Year 1 ↔ Year 2 r = .72, p < .001; Year 1 ↔ Year 3 r = .69, p < .001; Year 2 ↔ Year 3 r = .54, p < .001). Environmental mastery assessments

were also positively associated with environmental mastery assessments at every other time point (Year 1 ↔ Year 2 $r = .67$, $p < .001$; Year 1 ↔ Year 3 $r = .67$, $p < .001$; Year 2 ↔ Year 3 $r = .59$, $p < .001$). However, pulse pressure and environmental mastery at each time point were unrelated to one another at every time point.

4.3.2 Initial Levels and Changes in Pulse Pressure and Environmental Mastery

Pulse pressure and environmental mastery were examined with regards to everyday emotional experiences. Findings for models where positive affect was considered are shown in *Table 4.2*, and findings for models where negative affect was considered are shown in *Table 4.3*.

Men higher in positive affect variability were more likely to have higher pulse pressure in Year 1 ($b = 0.563$, $SE = 0.229$, $p = .014$). Men were more likely to show increases in pulse pressure over the three years if they were married to a spouse higher in positive affect variability ($b = 0.235$, $SE = 0.100$, $p = .018$). Men were also more likely to show increases in pulse pressure if they themselves were initially higher in mean levels of positive affect ($b = 0.173$, $SE = 0.085$, $p = .042$). Men who felt that their partner shared their feelings with them to a greater extent tended to have decreases in pulse pressure over the three years ($b = –0.171$, $SE = 0.052$, $p = .001$); this finding was specific to positive affect (negative affect model: $b = –0.040$, $SE = 0.030$, $p = .178$). No differences in either initial levels of or changes in pulse pressure over time emerged for women in terms of their positive and negative affect variability or initial levels or the degree to which they felt their partner was sharing their feelings with them (see *Tables 4.2* and *4.3*).

Women higher in mean positive affect were more likely to have greater perceptions of environmental mastery in Year 1 ($b = 0.021$, $SE = 0.008$, $p = .006$). Men were more likely to have greater perceptions of environmental mastery in Year 1 not only if they were lower in mean

negative affect themselves (b = –0.014, SE = 0.005, p = .003), but also if their spouse was lower in mean negative affect (b = –0.008, SE = 0.004, p = .049). Women higher in negative affect variability were more likely to have lower initial levels of environmental mastery in Year 1 (b = –0.037, SE = 0.012, p = .002), but were also more likely to show increases in environmental mastery over the following years (b = 0.017, SE = 0.007, p = .018). Greater perceptions of shared feelings were associated with higher initial perceptions of environmental mastery for women (b = 0.011, SE = 0.004, p = .007), and decreases in perceptions of environmental mastery over three years for men (b = –0.006, SE = 0.003, p = .045).

Older women were more likely to have higher initial levels of pulse pressure (negative affect model: b = 0.530, SE = 0.224, p = .018; positive affect model: b = 0.535, SE = 0.233, p = .022). Men who completed the study in English were more likely than men who completed the study in Mandarin to show increases in pulse pressure over three years (negative affect model: b = 2.336, SE = 0.986, p = .018; positive affect model: b = 2.502, SE = 0.915, p = .006). Older women were more likely to show decreases in environmental mastery over three years, but this association was only statistically significant in the positive affect model (b = –0.011, SE = 0.005, p = .020; negative affect model: b = –0.009, SE = 0.005, p = .064)[4]. For pulse pressure, the difference between the full model and the nested comparison model was not significant with negative affect ($\chi 2$(20) = 12.80, p = .886) or with positive affect ($\chi 2$(20) = 17.77, p = .603). However, the full model better fit the data compared to the nested comparison model for

[4] Follow-up analyses only included data from participants who completed at least one follow up assessment, and produced comparable results that only differed nominally from those presented here.

environmental mastery, both with negative affect ($\chi 2(20) = 83.65$, $p < .001$) and with positive affect ($\chi 2(20) = 71.99$, $p < .001$).

Table 4.1 Individual means, standard deviations, and intercorrelations of key study variables (N = 83 - 119 couples)

Variable	Wives *M (SD)*	Husbands *M (SD)*	1	2	3	4	5	6	7	8	9	10	11	12
1. Positive Affect Variability	9.09 (3.79)	8.31 (4.34)												
2. Negative Affect Variability	8.48* (4.14)	7.40* (4.11)	.62**											
3. Mean Positive Affect	67.84* (11.96)	71.08* (13.57)	–.19**	–.24**										
4. Mean Negative Affect	19.12** (12.58)	14.34** (11.03)	.05	.43**	–.48**									
5. Mean shared feelings	68.63* (13.86)	72.79* (15.55)	–.04	–.17**	.84**	–.51**								
6. Age	69.75** (5.52)	72.19** (6.24)	–.10	-.05	.03	-.04	–.02							
7. Language of Study Completion	0.72 (0.45)	0.72 (0.45)	.22**	.19**	.29**	–.10	.31**	–.30**						
8. Pulse Pressure (T1)	51.61 (11.47)	48.83 (11.45)	.12	.02	-.03	–.01	–.05	.17**	–.06					
9. Pulse Pressure (T2)	53.58 (12.46)	51.00 (11.93)	.09	-.06	-.06	.06	–.07	.13	.10	.72**				
10. Pulse Pressure (T3)	53.39 (15.02)	52.15 (12.91)	.12	.02	.02	–.03	–.00	.08	.08	.54**	.69**			
11. Environmental Mastery (T1)	3.96 (0.56)	4.02 (0.54)	–.08	–.31**	.44**	–.41**	.36**	.11	.09	.05	.01	.07		
12. Environmental Mastery (T2)	3.93 (0.56)	3.91 (0.54)	–.04	–.23**	.30**	–.35**	.20**	.02	.07	–.08	–.03	.04	.67**	
13. Environmental Mastery (T3)	4.03 (0.60)	4.06 (0.51)	.03	–.16*	.39**	–.39**	.27**	–.06	.24**	–.04	–.02	.03	.59**	.67**

Note. Gender coded as 0 = man, 1 = woman. Language of study completion coded as 0 = Mandarin, 1 = English. Paired sample t-tests were conducted to test mean differences between wives and husbands. Correlations are based on means that were aggregated across wives and husbands. * $p < .05$. ** $p < .01$.

Table 4.2 Dyadic latent growth curve models predicting initial levels and changes across time in pulse pressure and environmental mastery from positive affect variability (N = 119 couples)

	Pulse Pressure		Environmental Mastery	
Parameters	*b* (*SE*)	*P*	*b* (*SE*)	*p*
Intercept (H)				
x positive affect variability (H)	0.563 (0.229)	.014*	–0.006 (0.011)	.584
x positive affect variability (W)	–0.193 (0.246)	.432	0.020 (0.013)	.111
x mean positive affect (H)	0.014 (0.177)	.938	0.015 (0.009)	.094
x mean positive affect (W)	0.040 (0.093)	.670	0.007 (0.005)	.126
x shared feelings (H)	–0.024 (0.156)	.879	–0.002 (0.006)	.752
x age (H)	0.235 (0.213)	.271	0.011 (0.008)	.186
x language of study completion (H)	–0.629 (3.367)	.852	–0.042 (0.120)	.722
Intercept (W)				
x positive affect variability (H)	0.019 (0.236)	.937	0.000 (0.010)	.997
x positive affect variability (W)	0.252 (0.307)	.413	0.001 (0.014)	.956
x mean positive affect (H)	–0.015 (0.070)	.835	0.001 (0.004)	.701
x mean positive affect (W)	0.129 (0.188)	.494	0.021 (0.008)	.006**
x shared feelings (W)	–0.079 (0.149)	.597	0.001 (0.006)	.870
x age (W)	0.535 (0.233)	.022*	0.008 (0.008)	.323
x language of study completion (W)	–0.570 (2.454)	.816	–0.073 (0.118)	.534
Slope (H)				
x positive affect variability (H)	0.030 (0.101)	.770	0.005 (0.007)	.475
x positive affect variability (W)	0.235 (0.100)	.018*	–0.005 (0.007)	.487
x mean positive affect (H)	0.173 (0.085)	.042*	0.004 (0.005)	.424
x mean positive affect (W)	–0.051 (0.046)	.267	–0.003 (0.002)	.248
x shared feelings (H)	–0.171 (0.052)	.001**	–0.006 (0.003)	.045*
x age (H)	–0.070 (0.113)	.532	–0.003 (0.004)	.366
x language of study completion (H)	2.502 (0.915)	.006*	0.130 (0.075)	.080
Slope (W)				
x positive affect variability (H)	0.088 (0.143)	.539	0.003 (0.005)	.553
x positive affect variability (W)	0.018 (0.177)	.920	0.002 (0.008)	.812
x mean positive affect (H)	0.014 (0.055)	.803	–0.002 (0.002)	.334
x mean positive affect (W)	–0.123 (0.088)	.160	0.006 (0.005)	.179
x shared feelings (W)	0.080 (0.095)	.401	–0.003 (0.003)	.379
x age (W)	0.098 (0.147)	.504	–0.011 (0.005)	.020*
x language of study completion (W)	1.854 (1.388)	.182	0.068 (0.066)	.303
Covariance individual level				
Intercept (H) ↔ slope (H)	–13.126 (14.306)	.359	–0.028 (0.025)	.265
Intercept (W) ↔ slope (W)	–10.114 (11.263)	.369	–0.048 (0.034)	.150
Covariance couple level				
Intercept (H) ↔ intercept (W)	5.335 (18.042)	.767	0.034 (0.030)	.259
Slope (H) ↔ slope (W)	6.059 (7.682)	.430	0.016 (0.016)	.332
Intercept (H) ↔ slope (W)	–7.192 (12.623)	.569	–0.001 (0.018)	.938
Intercept (W) ↔ slope (H)	–6.599 (8.292)	.426	–0.009 (0.018)	.602
Residual (H) T1 ↔ Residual (W) T1	–0.677 (13.503)	.960	0.002 (0.029)	.963
Residual (H) T2 ↔ Residual (W) T2	0.593 (8.537)	.945	0.027 (0.025)	.284
Residual (H) T3 ↔ Residual (W) T3	21.530 (20.448)	.292	–0.008 (0.038)	.837

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

Table 4.3 Dyadic latent growth curve models predicting initial levels and changes across time in pulse pressure and environmental mastery from negative affect variability (N = 119 couples)

	Pulse Pressure		Environmental Mastery	
Parameters	*b* (*SE*)	*p*	*b* (*SE*)	*P*
Intercept (H)				
x negative affect variability (H)	0.401 (0.357)	.261	–0.019 (0.012)	.127
x negative affect variability (W)	–0.191 (0.270)	.480	0.006 (0.011)	.594
x mean negative affect (H)	–0.235 (0.120)	.050	–0.014 (0.005)	.003**
x mean negative affect (W)	0.077 (0.103)	.453	–0.008 (0.004)	.049*
x shared feelings (H)	–0.085 (0.073)	.243	0.003 (0.003)	.297
x age (H)	0.218 (0.204)	.287	0.012 (0.008)	.132
x language of study completion (H)	0.294 (3.006)	.922	0.101 (0.101)	.315
Intercept (W)				
x negative affect variability (H)	–0.042 (0.262)	.872	–0.009 (0.013)	.485
x negative affect variability (W)	–0.205 (0.285)	.472	–0.037 (0.012)	.002**
x mean negative affect (H)	0.038 (0.090)	.674	–0.001 (0.005)	.870
x mean negative affect (W)	0.030 (0.111)	.785	–0.004 (0.005)	.364
x shared feelings (W)	0.006 (0.088)	.943	0.011 (0.004)	.007**
x age (W)	0.530 (0.224)	.018*	0.014 (0.008)	.077
x language of study completion (W)	0.884 (2.490)	.723	0.103 (0.111)	.352
Slope (H)				
x negative affect variability (H)	–0.098 (0.127)	.439	0.006 (0.007)	.387
x negative affect variability (W)	0.199 (0.131)	.129	0.002 (0.007)	.768
x mean negative affect (H)	0.076 (0.063)	.227	–0.001 (0.004)	.734
x mean negative affect (W)	–0.050 (0.038)	.191	0.002 (0.002)	.241
x shared feelings (H)	–0.040 (0.030)	.178	–0.003 (0.002)	.034*
x age (H)	–0.059 (0.120)	.620	–0.005 (0.003)	.151
x language of study completion (H)	2.336 (0.986)	.018*	0.074 (0.058)	.200
Slope (W)				
x negative affect variability (H)	0.125 (0.182)	.492	0.004 (0.007)	.520
x negative affect variability (W)	–0.055 (0.140)	.696	0.017 (0.007)	.018*
x mean negative affect (H)	–0.015 (0.054)	.777	–0.002 (0.003)	.403
x mean negative affect (W)	–0.070 (0.058)	.225	–0.004 (0.002)	.100
x shared feelings (W)	–0.030 (0.051)	.551	0.000 (0.002)	.806
x age (W)	0.067 (0.140)	.633	–0.009 (0.005)	.064
x language of study completion (W)	1.533 (1.285)	.233	–0.011 (0.057)	.844
Covariance individual level				
Intercept (H) ↔ slope (H)	–13.847 (15.392)	.368	–0.015 (0.021)	.464
Intercept (W) ↔ slope (W)	–9.909 (11.284)	.380	–0.049 (0.034)	.149
Covariance couple level				
Intercept (H) ↔ intercept (W)	6.048 (18.985)	.750	0.039 (0.030)	.196
Slope (H) ↔ slope (W)	5.716 (8.277)	.490	0.018 (0.015)	.243
Intercept (H) ↔ slope (W)	–5.503 (12.292)	.654	–0.009 (0.018)	.624
Intercept (W) ↔ slope (H)	–5.313 (8.820)	.547	–0.014 (0.019)	.466
Residual (H) T1 ↔ Residual (W) T1	–0.754 (13.608)	.956	–0.005 (0.030)	.860
Residual (H) T2 ↔ Residual (W) T2	1.895 (8.473)	.823	0.028 (0.023)	.224
Residual (H) T3 ↔ Residual (W) T3	15.718 (19.962)	.431	–0.014 (0.031)	.638

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

4.4 Discussion

The main goal of this study was to explore concurrent as well as prospective associations between affect variability and physical and mental health. Spousal interrelations were taken into account, using data from a sample of community-dwelling older adult couples. Only men who were high in positive affect variability were more likely to have higher initial levels of pulse pressure, and only men who had a spouse high in positive affect variability were more likely to have steeper increases in pulse pressure. On the other hand, only women high in negative affect variability were more likely to have lower initial levels of environmental mastery, but also to have steeper increases in environmental mastery over time. Women who perceived their partner as sharing their feelings with them to a greater extent were more likely to have higher initial environmental mastery. Men with these perceptions were more likely to have steeper decreases in pulse pressure over time, but also steeper decreases in environmental mastery. Hence, both low affect variability and perceptions of being emotionally 'let in' by one's spouse were generally found to beneficially associate with physical and mental health; some exceptions are noted as well as their gender specificity.

4.4.1 Emotional Experiences and Pulse Pressure

Individual and dyadic associations between positive affect variability and pulse pressure emerged for men only. Findings replicate previous cross-sectional evidence based on unrelated individuals showing that high positive affect variability is associated with increased cardiovascular risk (Jones et el., 2020; Koval et al., 2013). This study extends the literature by providing initial evidence that one's partner's high positive affect variability is prospectively connected to increases in one's own cardiovascular risk (i.e. pulse pressure) over three years. Importantly, these longitudinal findings provide initial evidence for the time-ordering of

associations between affect variability and health indicators. Specifically, high spousal positive affect variability preceded increases in pulse pressure (although the design did not allow for testing the reverse order). Although I had no a priori hypothesis regarding gender differences, these findings only emerged for men. The gender specificity of these findings may be contextualized by previous research suggesting that older men often have less diverse networks, with spousal partners as their main source of social support (Antonucci & Akiyama, 1987; Birditt & Anotnucci, 2007; Gurung et al., 2003). Relative to women, perhaps men are particularly impacted by the emotional experiences of their spouse specifically in older age. Unexpectedly, high mean levels of positive affect were also associated with increases in pulse pressure over time, for men. Given that extant research suggests positive emotional experiences are protective of cardiovascular risk (Fredrickson & Levenson, 1998), this finding must be interpreted with caution and requires replication to avoid drawing premature conclusions.

4.4.2 Emotional Experiences and Environmental Mastery

On the other hand, associations between negative affect variability and environmental mastery emerged only for women. Specifically, women high in negative affect variability were more likely to initially be lower in environmental mastery. This finding is in line with previous research linking high emotional reactivity with low mastery in daily life (Neupert et al., 2007). However, women high in negative affect variability were more likely to have steeper increases in environmental mastery over time, which is opposite to what was hypothesized. Although this finding was unexpected, it may be contextualized in literature suggesting that affect variability may also capture flexible emotional responding to changing circumstances (Fleeson, 2004; Levy-Gigi, et al., 2016). Hence, I speculate that high negative affect variability may represent a double-edged sword, where it can result in accumulative wear-and-tear, but perhaps if one is able

to respond to changing circumstances, then that may be beneficial for building mastery over time. However, these ideas should be explicitly tested in confirmatory analyses and replicated. For men, lower mean levels of one's own negative affect, and lower mean levels of one's partner's negative affect, were associated with higher initial environmental mastery. These findings are in line with my hypotheses, and with previous literature suggesting that greater perceptions of control over desirable outcomes are associated with better emotional well-being (Kunzmann et al., 2002). Further, dyadic effects were again only observed for men, underlining ideas that men may be more impacted by their spouse's emotional experiences in older age than women.

4.4.3 Perceptions of One's Spouse Sharing Their Feelings: A Double-Edged Sword?

While greater perceptions of one's spouse sharing their feelings were expected to be have generally beneficial associations with the targeted physical and mental health indicators, findings suggest a double-edged sword effect, especially for men. While women who perceived their spouse as sharing their feelings with them to a greater extent were more likely to have higher initial environmental mastery, men with similar perceptions were more likely to show steeper decreases in pulse pressure over three years, but also steeper decreases in environmental mastery. These findings are partially in line with extant research which suggests that being 'let in' by one's spouse is beneficial for health and relationship functioning (Driver & Gottman, 2004; Haase et al., 2016), and provide initial evidence for shared feelings as a potential mechanism underlying previous observations that high quality marriages are protective for cardiovascular health (Holt-Lunstad et al., 2008). However, these findings also suggest that greater perceptions of one's spouse sharing their feelings is not ubiquitously positive. I speculate that men who are more aware of their spouse's feelings may also be more impacted by them, and perhaps feel less

in control over their environment over time if they are more aware of emotions that are not their own and thus less under their own control.

4.4.4 Limitations and Future Directions

Individual and spousal affect variability were explored in connection with concurrent levels as well as longitudinal changes in pulse pressure and environmental mastery, two key physical and mental health indicators in old age. Examining longitudinal associations between affect variability and health in both partners allowed me to extend a largely cross-sectional literature based on individuals, as well as partially speak to the time-ordering of associations between emotional experiences and health. Nevertheless, the current study must be considered in view of several limitations.

Although the longitudinal design involved three annual assessments of pulse pressure and environmental mastery, affect variability was only measured once, at the first assessment point. The current literature on affect variability and health would benefit from a disentanglement of the time-ordering of associations: does affect variability precede or follow health problems? Affect variability was only measured at baseline, and thus these findings can only address one possible temporal order, suggesting that affect variability precedes changes in pulse pressure and environmental mastery. Because the measurement of affect variability requires repeated daily life assessments from the same individual over several shortly-spaced time points (i.e. several times per day over several days), future research should consider implementing ‘measurement burst’ designs (Nesselroade, 1991; Sliwinski, 2008), where repeated daily life assessments are repeatedly obtained over longer periods of time (e.g. annually). Further, the longitudinal design in the current study allowed for an examination of changes in pulse pressure and environmental mastery over a three-year period, using a latent growth modelling approach. While having three

assessment points does allow for an investigation of the change process over time, it is the minimum, and more assessment points would be ideal for the estimation of latent slopes (Singer & Willet, 2003).

Another notable measurement issue is that environmental mastery was measured by a three-item scale (Ryff, 1989). Although this short scale has shown adequate reliability in previous research (Ryff, 1989), reliability in this study was moderate across measurement points (ranging from .62 – .66). Given that the scale only includes three items, one of which is reverse-coded, this is not surprising, but warrants acknowledgement as a limitation. Future research specifically focusing on this question should consider including a more comprehensive and reliable measure of environmental mastery.

Lastly, an important limitation of the current analytic models is that in order to account for between-person differences in timing of annual assessments, traditional fit indices were not available. A relative fit index was used instead, from which I can only conclude whether the model of interest fits the data better than a comparison model (e.g. one that only includes covariates). In the current research, environmental mastery showed good relative fit, while the model for pulse pressure did not fit the data better than the comparison model. I interpret these model fits with caution, keeping in view that they are based on relative rather than traditional fit indices. However, I speculate that the model fit may be understood in light of the sample as well as the limited longitudinal assessment points. Extant research suggests that older adults are more vulnerable to increased cardiovascular risk (Franklin et al., 1997; Kannel & Gordon, 1978; Knight et al., 2001) and decreased mastery over daily life circumstances (Robinson & Lachman, 2017; Ryff, 2008). However, not all adults age in the same way. While the current research is based on a sample of relatively healthy and community-dwelling older adult couples, the change

process in pulse pressure and environmental mastery may be accelerated in more vulnerable populations of older adults. Further, longitudinal data are only well-suited for investigations of change over time if the variables of interest follow a change process that is concordant with the measurement intervals (Collins, 2006). While having three annual assessment points does allow for an investigation of the change process over years, more assessment points would be ideal for the estimation of latent slopes (Singer & Willet, 2003), particularly for older samples, for whom change is often heterogeneous.

4.4.5 Conclusions

Considered in sum, this study builds on previous evidence connecting affect variability with physical and mental health, by taking longitudinal and dyadic associations into account. Generally, higher individual and spousal affect variability was adversely related to physical and mental health, while greater perceptions of one's spouse sharing their emotions showed beneficial associations, although with notable exceptions. Importantly, findings point to the gender-specificity of findings, suggesting that physical and mental health benefits may be conferred through different mechanisms for husbands and wives in older age.

Chapter 5: General Discussion

5.1 Synthesis

Meaningful social interactions are increasingly prioritized with aging (Carstensen et al., 2003; Carstensen et al., 1999; English & Carstensen, 2014). Spouses especially play an important role in coping with health problems (Berg & Upchurch, 2007; Stephenson et al., 2014) and are well-situated to shape each other's physical and mental health trajectories (Michalowski et al., 2018). Building on my conceptual model (*Figure 1.1*), I investigated dyadic linkages in emotional experiences in the everyday lives of older adult couples (Chapters 2 through 4), in connection to proximal (Chapter 3) and distal (Chapter 4) health indices. Specifically, I focused on the dynamic, fluctuating nature of emotional experiences, given previous research linking affect variability with health (Hardy & Segerstorm, 2016; Ong & Ram, 2017; Röcke & Brose, 2013).

Taken together, findings highlight that emotional experiences are closely intertwined in older couples (Chapters 2 through 4). The goal of Chapter 2 was to examine the role of fluctuating happiness for how well one is able to gauge the happiness of one's spouse in everyday life. Greater fluctuations in one's own happiness tended to promote accurately gauging the happiness of one's spouse, but they were not any more or less helpful for being accurately read oneself. Notably, findings replicated across two samples of community-dwelling older adult couples. Chapters 3 and 4 went on to show that not only are one's own emotional experiences connected with one's health, but that the emotional experiences of one's partner also matter, across both proximal (salivary cortisol) and distal (pulse pressure, environmental mastery) health indices.

Across Chapters 2 through 4, I found that perceptions of one's spouse sharing their feelings (being 'let in' emotionally) in everyday life were generally beneficial. As a main effect, greater perceptions of shared feelings were associated with improved time-varying empathic accuracy (pattern accuracy) for happiness (Chapter 2). Momentary increases in spousal contentment tracked with reductions in salivary cortisol levels, only when one perceived their spouse to be sharing their feelings more than usual (Chapter 3). Greater perceptions of shared feelings as a main effect were also associated with reduced cortisol levels overall (Chapter 3). In Chapter 4, greater perceptions of shared feelings were linked with higher environmental mastery in wives (Chapter 4), and steeper decreases in pulse pressure over three years in husbands (Chapter 4). However, findings also suggest that while shared emotional experiences within marriage may represent a resource, they also introduce vulnerabilities. Chapter 3 showed that increases in one's spouse's sadness were only associated with concurrent increases in one's own cortisol levels if perceptions of shared feelings were greater than usual. Chapter 4 then provided initial evidence for greater perceptions of shared feelings linking with steeper decreases in environmental mastery for men. Hence, while being 'let in' may be generally beneficial, my findings also suggest a double-edged sword effect.

Building on ideas presented in my conceptual model (*Figure 1.1*) that short-term variability can accumulate into longer-term change within couples, associations between fluctuating emotional experiences and health indices were examined across different timescales. Chapter 3 investigated such associations in a proximal context, namely, the everyday lives of older couples. Emotional experiences were found to wax and wane with momentary cortisol: higher momentary sadness co-varied with higher momentary cortisol levels, while higher momentary contentment co-varied with lower momentary cortisol levels. Similar patterns were

observed between one's own cortisol and one's partners emotional experiences (provided that one perceived their partner as sharing their feelings more than usual). Chapter 4 went on to explore the longer-term physical (pulse pressure) and mental (environmental mastery) health implications of short-term emotional fluctuations, using longitudinal data gathered over three years. Men higher in positive affect variability were more likely to have higher initial levels of pulse pressure. Additionally, men who had a spouse high in positive affect variability were more likely to show steeper increases in pulse pressure. On the other hand, women high in negative affect variability were more likely to have lower initial environmental mastery, but steeper increases in environmental mastery. Hence, less favorable initial levels of and changes in pulse pressure and environmental mastery were generally associated with higher affect variability, although these associations were mixed and specific to emotional valence as well as gender.

Taken together, this dissertation shows that a consideration of both spousal interrelations and different timescales is required for contextualizing connections between dynamic, socially interconnected emotional experiences and health. Findings highlight dyadic links in emotional experiences (Chapters 2 through 4), and the role of the spouse for associations between fluctuating emotional experiences and health across different timescales (Chapters 3 and 4). Greater fluctuations in one's own happiness tended to facilitate accurately gauging the happiness of one's spouse (Chapter 2), and being 'let in' emotionally by one's spouse was generally beneficial (Chapters 2 through 4). However, being exposed to the emotional experiences of one's spouse may not be unanimously positive, but rather represents a double-edged sword (Chapter 3 and 4).

5.2 Strengths, Limitations, and Future Directions

5.2.1 Ideal Timescales for Measuring Variability and Change

Examining variability and change requires repeated measures designs, where transient states (e.g. emotional experiences) and cumulative changes (e.g. changes in health) are assessed multiple times within the same individual. Although variability and change can be captured from as few as three assessment points (Boker & Nesselroade, 2002), it is a methodological and conceptual challenge to pinpoint the ideal timing and spacing of repeated assessments. In tandem with methodological considerations, the timing and spacing of assessments must also be determined on conceptual grounds and should be largely dependent on the constructs of interest (Röcke & Brose, 2013).

One challenge that arises is what to do when different constructs have ideal measurement timescales that are not identical. For example, in healthy samples, cortisol follows a diurnal daily rhythm: there is a peak 30 minutes after waking, followed by a gradual decline throughout the remainder of the day (Kudielka et al., 2012). Capturing this diurnal rhythm requires assessments at waking, 30 minutes after waking, and evenly spaced times throughout the rest of the day. In contrast, fluctuations in emotional states may be relatively fast-moving and less patterned in time. For instance, evidence from healthy young adult samples suggests that positively valenced emotions may also follow a diurnal rhythm (U-shaped, lowest in the morning and evening), but negatively valenced emotions show less temporal variation (Murray et al., 2002; Watson, 2000). In this dissertation, emotional experiences were not only conceptualized as dynamic but also as interpersonal (Butner, 2015). Hence, procedures were designed with an eye on the diurnal nature of cortisol, as well as the dynamic and interpersonal nature of emotional experiences.

Data from both samples (Linked Lives project in Vancouver, Canada; and Berlin Couples Dynamics project in Berlin, Germany) were obtained at 4 to 6 evenly spaced times per day, over 7 consecutive days, as older adult couples engaged in their everyday routines. Assessments were completed simultaneously by both partners, in order to observe interpersonal processes as they unfold over time in naturalistic contexts (Laurenceau & Bolger, 2005). There was a cortisol assessment 30 minutes post-waking (in line with requirements to capture diurnal rhythms; Kudielka et al., 2012), but no corresponding assessment of emotional experiences. Because concurrent fluctuations in cortisol and emotional experiences were of interest in Chapter 3, the 30 minute post-waking cortisol assessment was not used in this dissertation. However, other analyses coming from the larger project may be interested in daily cortisol profiles, rather than momentary fluctuations, which could require a 30 minute post-waking assessment. If the focus of the larger project had been on emotional experiences only, fewer days and more closely spaced intervals may have been ideal. Ultimately, the choice of the repeated daily life assessment schedule for examining emotional experiences and health is a complex judgement call (Larsen, 2007; Gerstorf et al., 2014). The procedures used in this dissertation required a balance of conceptually complementary, but also methodological competing, constructs. The following section discusses strengths of the methodological approach used in collecting data for this dissertation, along with key limitations.

First, the assessment schedule was fixed at the same equally spaced times each day. This approach allowed me to capture the diurnal rhythm of cortisol, while matching it with corresponding assessments of emotional experiences. It also ensured that assessments from both spouses could be completed simultaneously. However, emotional experiences can be transient and fast-moving, and considering my interest in fluctuations, I may have risked missing key

changes by capturing emotional experiences at fixed times (i.e. approximately every four hours). One alternative to this approach may be to prompt assessments when emotion-eliciting events occur. However, a challenge then becomes to determine the base rate of such events in daily life settings. To achieve sufficient power for connecting emotional experiences to, for example, stressors or social interactions, in community-dwelling older samples, larger sample sizes or longer assessment periods may be needed. Nevertheless, connecting fluctuating emotional experiences to specific everyday situations offers a complementary perspective by pinpointing which fluctuations may be especially relevant for physical and mental health.

Another alternative scheduling option is to have randomized assessment points throughout the day (e.g. a variable schedule). Variable schedules allow for a generalization of momentary associations to any moment in the day, rather than only the chosen times of day. They also reduce the risk of participants adjusting their emotional states in anticipation of an assessment (although there is limited evidence for continued reactivity and self-monitoring over many repeated measurements; Bolger et al., 2003). However, a significant advantage of the chosen fixed schedule over a variable one is that set assessment times limit unwelcome surprises and potential for interference with the daily routines of older aged samples. In support of this argument, Linked Lives participants indicated (on a scale from 1 = “not at all” to 5 = “very much”) that questionnaire completion minimally interfered with their daily routines (M = 2.24, SD = 0.93) or resulted in changed behavior (M = 1.79, SD = 0.93), and that days of participation were relatively typical of their everyday lives (M = 3.79, SD = 1.06). Taken together, the choice of whether to adopt a fixed, event-based, or variable schedule for everyday repeated assessments depends on the everyday events that the timing corresponds to, the relevancy of the chosen

construct to the sample, and feasibility according to capabilities and preferences of the sample of interest.

In addition to the timing of assessments, there is also the question of the frequency and spacing needed to adequately measure variability and change. From a methodological point of view, an overly dense or frequent assessment schedule may introduce measurement issues (e.g. habituation, fatigue; Bolger et al., 2003); on the other hand, too sparse or few assessment points can create problems with internal consistency and risk missing key changes (Boker et al., 2009; Ram & Gerstorf, 2009). A minimum of three assessment points is generally required for studies of dynamic processes (Boker & Nesselroade, 2002). However, affect variability in older adults has been captured through a wide range of assessment points, with as many as 100 daily assessments (Brose et al., 2013), and as few as 6 daily assessments (Human et al., 2015). From a conceptual standpoint, the ideal number of assessment points for assessing affect variability may also vary depending on emotional valence. Given that older adults generally report more variability in positively valenced emotions, relative to negative ones (Röcke et al., 2009), more assessment points may be needed to reliably tap into negative affect variability, relative to positive affect variability. Currently, there is a lack of consensus in common standards for measuring affect variability (Brose et al., 2019), and the choice of timing and spacing of assessments may ultimately rely on conceptual reasoning (Boker et al., 2009; Bolger et al., 2003; Ram & Gerstorf, 2009).

Lastly, this dissertation aimed to connect short-term variability in emotional experiences to longer-term changes in health. Effectively tracking long-term changes requires the change process to align with measurement intervals (Collins, 2006). I used three annual assessments of pulse pressure and environmental mastery in Chapter 4 to examine changes in health over time.

While three measurement points are sufficient for tracking change, I was restricted to examining linear change. A greater number of annual assessments would have been ideal for examining more complex patterns and for the estimation of slopes (Boker & Nesselroade, 2002; Singer & Willet, 2003). In an ideal scenario that overcomes funding and logistical barriers, I would be interested in seeing future research that not only connects affect variability to many more annual health assessments, but that also measures affect variability annually, through a 'measurement burst' design (Nesselroade, 1991; Sliwinski, 2008). Embedding repeated daily life assessments into annual 'bursts' of data collection, for example, allows not only for a connection of short-term fluctuations with longer-term outcomes, but also for observing longer-term changes in the short-term fluctuations themselves. For example, previous work has shown that affect reactivity to stressors actually tended to increase within individuals over 10 years (Sliwinski et al., 2009). Further, the directionality between fluctuations in emotional experiences and changes in health remains an open question, but may be answered if multiple measures of affect variability are collected in tandem with annual health assessments. While the findings in this dissertation provide initial evidence for associations between affect variability and longer-term health indices, the literature would benefit from methodological extensions that consider simultaneously integrating multiple timescales (Gerstorf et al., 2014).

5.2.2 Momentary and Retrospective Reports

Another intriguing question for future research is whether retrospective or momentary reports are best-suited for measuring variability and change. Generally, retrospective reports ask participants to reflect across varying time intervals (days, weeks, months, years). On the other hand, momentary reports ask participants to report their current state and are ideally suited to track fast-moving processes. However, this distinction can become artificial, especially when

participants are asked to reflect over short periods of time. In the health psychological tradition, classic daily diary designs often involve waking and/or evening assessments (e.g. Beggs et al., 2016; Bolger et al., 2003), which ask participants to reflect on the current day. Related approaches stem from the social psychological literature, such as the Day Reconstruction Method (Kahneman et al., 2004), and the lifespan literature, such as the Yesterday Interview (Moss & Lawton, 1982), both of which ask participants to recall the previous day. In choosing between designs, key considerations include recall bias concerns, between-person characteristics of respondents, and the timescale on which within-person variability occurs (Bolger et al., 2003; Hoppmann & Riediger, 2009; Lay et al., 2019; Röcke et al., 2011).

There are unique advantages and disadvantages to each approach. Momentary assessments have the advantage of minimizing recall bias and make it possible to connect time-varying constructs on the same timescale. In the current dissertation, I used momentary assessments to connect fluctuations between an objective physiological measure (e.g. salivary cortisol, Chapter 3) with fluctuations in a subjective psychological state (e.g. emotional experiences). Momentary assessments are well-suited for tracking fast-changing processes, such as dynamic interpersonal processes (Laurenceau et al., 1998; Laurenceau & Bolger, 2005; Hoppmann & Riediger, 2009). However, they have the disadvantage of placing a high burden on the participant (e.g. several assessments that must be completed at specific times throughout the day, for several days). Simply adhering to momentary study protocols requires significant time and effort from participants, and can be cognitively demanding, potentially limiting participation in aging studies to high functioning older adults. An advantage of daily diary designs, in contrast, is that they may be better suited for reaching harder to recruit populations that may be coping with significant challenges, because assessments that take place at the beginning and/or end of

the day are less demanding than those that take place several times per day. Further, it is feasible for daily diary assessments to be administered by phone, which may also be more feasible for populations coping with specific challenges, such individuals living with the effects of rheumatoid arthritis who have tactile limitations (e.g. Beggs et al., 2016). Hence, while participants in the samples of community-dwelling older adults included in the current dissertation were able to complete multiple daily life assessments, reaching a wider range of older adults would require careful considerations of study procedure feasibility.

Momentary and daily diary designs minimize recall biases that have been shown to influence retrospective self-reports (Bolger et al., 2003; Schwarz, 1999). Indeed, between-person personality traits, such as neuroticism and extraversion amplify discrepancies between momentary and retrospective reports of emotional experiences (Lay et al., 2019). While between-person ratings of emotional experiences averaged across moments seem to correspond well with retrospective reports of emotional experiences in older adults (Röcke et al., 2011), within-person variations may be best captured with momentary or daily diary assessments (Bolger et al., 2003; Hoppmann & Riediger, 2009). Depending on the targeted question, there could be a middle ground. For example, the day reconstruction method has been found to produce comparable estimates of intensity and variation in affect over a day, relative to momentary reports (Dockray et al., 2010). Previous research has used this approach to compute affect variability from a single day reconstruction assessment, where variability in emotional states was computed from an average of 11 episodes recounted from the previous day (Daly et al., 2014). However, concerns about recall bias, directing attention to discrete events, and the representativeness of the previous day remain a concern in these approaches, especially in light

of increasingly convenient and accessible administration of momentary reports through modern electronic devices (Diener & Tay, 2014).

5.2.3 Gender Differences in Self-Reports

Self-reports may systematically differ between women and men. Stereotypes of emotional experiences follow gendered beliefs, and are in line with social definitions of masculinity and femininity suggesting that women have more intense and reactive emotional experiences than men (Robinson & Clore, 2002; Shields, 1995). Interestingly, gender differences are more reliably found in trait measures of emotionality (Feldman-Barret et al., 1998), but less so in repeated daily life assessments of emotional experiences (Reis & Wheeler, 1991). Hence, one pathway through which gender differences in emotional experiences may emerge could be through gendered beliefs, particularly in global, retrospective self-reports (Robinson & Clore, 2002). Further, gender differences in self-reported emotions seem to become attenuated with age, especially after the age of 70 (Consedine et al., 2005; Labouvie-Vief et al., 2003). In support of this notion, men and women do not seem to differ in cardiovascular reactivity to emotional stimuli in older age (Kudielka et al., 2004; Labouvie-Vief et al., 2003; Uchino et al., 1999).

In the current dissertation, gender differences were always examined, but no gender differences were observed in Chapters 2 and 3. In Chapter 4, gender differences were implicit in the analytic strategy, since initial levels and changes in mental and physical health indicators were modelled as separate, but correlated, for husbands and wives. Although the current dissertation did not specifically focus on gender differences, greater affect variability (both individual and spousal) was related to less favorable pulse pressure profiles for men only. I interpret this finding to be reflective of older men tending to rely on their spouse as their main source of social support, relative to women, in older age (Antonucci & Akiyama, 1987; Birditt &

Anotnucci, 2007; Gurung et al., 2003), and perhaps indicative that men may be particularly impacted by the emotional experiences of their spouse with age. However, other research suggests that women are more emotionally and physiologically influenced by their partner's distress (Behler et al., 2019; Slatcher et al., 2011). Hence, considering the exploratory nature of findings in Chapter 4, further confirmatory research and replication is needed to contextualize these results. Taken together, while gender differences in emotional experiences are reported in the literature (Robinson & Clore, 2002), these may be more pronounced in retrospective trait measures and in younger samples.

5.2.4 Assessing Cortisol in Daily Life

Biomarkers, such as cortisol, in repeated daily life assessment studies are more 'objective' indicators than self-reported emotional experiences. However, cortisol assessments are still prone to measurement error, given that participants took salivary samples several times in their own daily lives. Adherence concerns have to be navigated in procedure designs and data cleaning, especially for older adults with potential memory problems (Hoppmann & Riediger, 2009; Kudielka et al., 2012), so that they do not create issues for data interpretation. Given the time-sensitive nature of cortisol indices (with some more sensitive than others; Kudielka et al., 2012; Stalder et al., 2016; Segerstrom et al., 2014), timing of assessments has to be optimized through careful methodological considerations in the design of study protocols, participant compliance, and data cleaning procedures.

In the Linked Lives study, procedures were put in place to maximize participant compliance to the sampling protocol. During an in-lab session, participants were given a large bag, which contained several smaller bags labelled by day (day 1, day 2, day 3, and so on), which contained individually labelled saliva sample tubes ('Salivettes') labelled by assessment

point. Along with these materials, trained research assistants provided participants with detailed instructions and plenty of time for questions, and were reachable during the week of participation for further questions. Participants recorded which samples were used on timestamped electronic questionnaires, administered on tablet computers. Other devices such as memory caps (a device that resembles a medication bottle and automatically records when it is opened) have a similar advantage of automatically timestamping when the lid is opened. However, they are not capable of recording whether the correct sample was taken at the right time. An advantage of using tablet computers is that participants can use the device to record which sample was used, although there is a risk that participants incorrectly report which sample was taken. Post data collection procedures involved a careful examination of these reports by: comparing electronic records to activity logs, examining accelerometry data (i.e. physical activity from waking to bedtime), plotting daily cortisol profiles for biological plausibility, and investigating implausibility on a case-by-case basis (Hoppmann et al., 2018). Hence, pre and post data collection procedures were designed to maximize confidence in the interpretation of resulting cortisol data.

5.2.5 Cohort Specificity

Inherent in studies of aging is the question of whether observed age differences or within-person development is due to normative accumulated life experiences over time (age effects), large scale events occurring in historical time (period effects), or a combination of both, where life experiences differentially shape development based on when one was born (cohort effects); all three effects are interrelated and may interact with each other (Alwin et al., 2002; Hülür, 2020). In other words, the same large scale events that shape the lives of many individuals are differentially impactful depending on the life phase one is in. For example, the Great Depression shaped the development of children differently from adults who experienced the economic

hardship at a different developmental phase in life (Elder, 2018). Previous evidence on age differences in emotional experiences typically relies on designs that compare two age groups (e.g. younger versus older adults), or that repeatedly measure the same or different individuals longitudinally. However, neither set of designs is capable of isolating age effects from the context in which the lived experiences of each generation unfold (Alwin et al., 2006; Alwin et al., 2002).

A limitation of the current work is that I cannot assume my findings generalize to other cohorts. Indeed, existing research does point to potential cohort differences in the health and psychosocial functioning of older adults. For example, evidence from the Berlin Aging Study I and II suggests that later-born cohorts have better cardiovascular health (König et al., 2018), as well as improved cognitive performance and higher subjective well-being (with declines towards the end of life; Gerstorf et al., 2015; Gerstorf et al., 2011; Hülür, 2020). These trends suggest that older adults in the current generation may be enjoying better physical and mental health relative to generations described in previous research. Interestingly, initial evidence from the Health and Retirement Study suggests that marriage is similarly protective of health for women belonging to birth cohorts before and early into the baby boom (Newton et al., 2014). Taken together, the generalizability of the current research to future cohorts is an open question. The positive trends observed for current later born cohorts of older adults may or may not continue for future cohorts, considering changing trends in population aging, onset of retirement, and technological advances (Gerstorf et al., 2020).

5.2.6 Sample Considerations

This dissertation focused on community-dwelling samples of older adult couples. Couples were recruited from the community, were required to be at least 60 years of age, and to

participate with their partner at the same time. Notably, participation was available in English, Mandarin, and Cantonese, in an effort to tap into different backgrounds in the local community. Approximately 30% of the Linked Lives sample identified as Asian and opted to complete procedures in Mandarin (although participation in Cantonese was also possible). The remaining participants predominantly identified as Caucasian and completed procedures in English. A strength of the presented research is that I was able to replicate findings across two culturally diverse samples (couples residing in Berlin, Germany, as well as in Vancouver, Canada; Chapter 2), and connect fluctuating emotional experiences and with both proximal and distal health indices (Chapters 3 and 4). The degree to which recruitment for and adherence to these study protocols would be feasible with more challenged populations remains an open question.

While a diverse population of older adult couples was targeted, older adults who volunteer for research studies generally over-represent the healthiest and happiest cross-section of this population (Golomb et al., 2012). Indeed, the couples who self-selected into participating in the current research were relatively healthy and high-functioning. Demanding study protocols likely restricted the heterogeneity of health profiles that exist in older adulthood. In order to be able to participate, eligible couples: had to have adequate vision and hearing capabilities; could not be diagnosed with neurodegenerative disease or brain dysfunction; could not be diagnosed with any health conditions that limited their physical activity; and were not asked to provide cortisol samples if they had been diagnosed with thyroid dysfunction or other conditions impacting HPA functioning. In line with these requirements, participating couples generally reported high self-rated health. Furthermore, couples reported high relationship satisfaction, were married for a long time, and were cognitively fit. It is important to acknowledge that many aging spouses are not as privileged. Many may be coping with significant health problems such as

dementia (Lyons et al., 2002) or arthritic conditions (Stephenson et al., 2014), and the findings of the current research may or may not transfer to more challenged cross-sections of older adult populations.

In fact, the boundary conditions of linkages between affect variability and health may be more readily observed in samples dealing with identified challenges, by tapping into a broader continuum. For example, previous research has fruitfully examined such linkages in samples coping with diverse sets of challenges, such as an affective disorder (e.g. borderline personality disorder; Trull et al., 2008), demands arising from conflicting life domains (e.g. working parents with small children; Human et al., 2015), or chronic health conditions (e.g. couples coping with type I diabetes; Berg et al, 2020). Hence, I would expect that linkages between affect variability and health may be amplified in older adults coping with challenging circumstances, while they may be more difficult to detect in less challenged segments of the population. One pathway by which associations between affect variability and health may differ in magnitude among different samples is through differential vulnerability to the occurrence of daily stressors. For example, in a sample of recently bereaved widows, stressful events in daily life seemed to beget further stressful events in less resilient individuals (Ong et al., 2006). Hence, when coping with age-related challenges, there may be heterogeneity within samples, which may be more obvious in samples that are representative of the most resilient as well as the most vulnerable.

The implications of coping with challenges may be especially relevant for older adults. The Stress Vulnerability and Integration model (Charles, 2010) predicts that while older adults may report fewer stressors in their daily lives, relative to younger adults, older adults are equally or more affected by stressors when they do occur. Older adults who are coping with health problems may be even more vulnerable. For example, in a sample of individuals living with type

I diabetes, compared to younger adults, older adults indeed reported fewer diabetes-related stressors and general stressors in their daily lives, but they still reported similarly reduced positive affect, increased negative affect, poorer blood glucose management, and worse self-care in response to stressors when they did occur (Berg et al., 2020). Hence, it seems reasonable to expect that more extreme expressions of fluctuating emotional experiences and their health correlates and consequences may be found in vulnerable samples, which would complement the findings based on community-dwelling older adult couples presented in this dissertation.

Lastly, recent years of research on fluctuating emotional experiences have seen an increasing recognition and reconciliation of questions regarding the ideal magnitude of affect variability (Human et al., 2015; Jones et al., 2020). In clinical populations, there is a recognition that while high affect variability can be indicative of dysfunction (e.g. borderline personality disorder; Trull et al., 2008), low affect variability or flat affect may also a symptom of mental health conditions (e.g. depression; Kuppens et al., 2007). Overall, participants in the community samples included in this dissertation were high-functioning. Accordingly, I conceptualized high affect variability as indicative of struggling to maintain stable emotional responding to everyday circumstances, and low affect variability as indicative of maintaining an emotional 'homeostasis,' in that the individual successfully adapted to their everyday routines (Röcke & Brose, 2013). However, perhaps more extreme manifestations of affect variability would come about in samples coping with challenges. For example, in a sample of dual-earner parents with small children as well as a sample of older adult individuals, moderate affect variability (neither especially high, nor low) was associated with more favorable daily cortisol profiles (Human et al., 2015). Further, in a racially and economically diverse sample of young to middle aged adults, moderate affect variability was associated with lower C-reactive protein (an index of systemic

inflammation), relative to high and low affect variability (Jones et al., 2020). In the community-dwelling older adult samples examined in the current research, I did not observe these curvilinear associations, possibly because the range of affect variability was restricted. Hence, associations between affect variability and health must be contextualized within the samples under observation, and research extensions should consider examining the boundary conditions of these associations among variously challenged samples.

5.2.7 Complementary Experimental Paradigms

While the data of this dissertation have many strengths (e.g. ecological validity, simultaneous reports from both partners, corresponding salivary cortisol assessments, health indices across proximal and distal timescales), a key limitation is that all findings reported here are correlational, and therefore do not allow for causal inferences. Indeed, associations between emotional experiences and health are often bidirectional: frequent negative emotional experiences may contribute to the development of health conditions, while being confronted with health challenges also likely contributes to more frequent negative emotional experiences (Kunzmann et al., 2019). Further, while the current data can speak to fluctuating emotional experiences as they occur in daily life, I did not measure emotional responses to specific stimuli. The observational findings presented here present a stepping stone for future research to pinpoint causal mechanisms under controlled laboratory conditions.

There is an extant literature on age-related changes in emotional experiences and emotion regulation in the laboratory that dovetails with socio-emotional theories of aging (Stanley & Isaacowitz, 2014). Central tenets of Socioemotional Selectivity Theory (Carstensen et al., 2003; Carstensen et al., 1999) suggest that older adults are more likely to be motivated to prioritize positive emotional experiences and meaningful social interactions. Indeed, experimental work

shows that older adults are more likely than younger adults to attend to and recall positively valenced stimuli, such as smiling faces, over negatively valenced stimuli (i.e. 'positivity effect'; Mather & Carstensen, 2005; see Reed et al., 2014 for a meta-analysis). However, meaningful social interactions in older age can also involve negative emotional experiences that require regulation (Berg et al., 1998; Coats & Blanchard-Fields, 2008). Hence, an intriguing challenge for experimental work could be to examine how older adults reconcile pushes and pulls between conflicting priorities, such as when a meaningful relationship introduces emotional vulnerabilities. Initial work suggests that 'positive sentiment override' (a positivity bias towards close relationships partners; Story et al., 2007) may be one pathway by which older adults maintain emotionally satisfying experiences in the face of problems. For example, during an in-lab marital disagreement task, older adults were more likely than middle-aged adults to rate their spouse's behaviour as more positive than independent observers, with marital satisfaction mediating this effect (Story et al., 2007). It would be interesting to extend this work by examining health-related discussions in couples coping with significant challenges, to better understand the mechanisms by which older spouses may attain emotional resilience in difficult situations.

Another intriguing laboratory-based paradigm that lends itself especially to examining fluctuations in emotional experiences is the use of an affect rating dial during in-lab marital interactions (Gottmann & Levenson, 1985; Ruef & Levenson, 2007). A strength of this method is that it captures fast-changing emotional states and is relatively unobtrusive to ongoing in-lab tasks; a corresponding limitation is that it involves polarizing emotional states into positive and negative, excluding more nuanced or overlapping emotional states (Ruef & Levenson, 2007). Using the affect rating dial, future experimental work may consider examining the variability of

affect ratings during tasks that are likely to elicit strong emotional responses, such as marital disagreements or discussions about health problems. Shifting focus beyond the individual, partners could also rate each other's affect continuously during such tasks, which would be an interesting approach to build on empathic accuracy findings presented in Chapter 2. Admittedly, engaging in parallel ongoing tasks represents an ideal scenario, but would be cognitively demanding and require modification to be feasible for more challenged populations. Extant experimental work suggests that compared to younger adults, the emotions of older adults are harder to read, and that older adults also have more difficulty reading the emotions of others (Ruffman et al., 2019). Similarly, older adults are worse at detecting deceit, relative to younger adults, perhaps due to older adults' attentional preferences for positive emotions over negative ones (Stanley & Blanchard-Fields, 2008). At the same time, findings from naturalistic settings suggest that older adults may be able to capitalize on their experiences to accurately infer the emotions of their spousal partner when they are absent (Rauers et al., 2013). Hence, while there are well-documented age differences in emotion recognition and expression, older spouses may be able to draw on their wealth of past experiences to accurately infer each other's emotional states. An interesting extension of Chapter 2 and existing experimental work on empathic accuracy could be to test the boundaries of age-differences. For example, using affect rating dials, participants could rate the emotions of strangers versus marital partners, as well as during positively valenced tasks versus negatively valenced ones. In line with previous research (e.g. Gould & Dixon, 1993; Kunzmann & Gruhn, 2005; Sansone & Berg, 1993; Schnitzspahn et al., 2012) I would expect that older adults may perform as well as younger adults when presented with emotionally and interpersonally relevant stimuli.

Experimental paradigms may also be useful for disentangling links between cortisol (the proximal health index of interest in Chapter 3) and emotional experiences within couples. The primary experimental approach that comes to mind is the classic Trier Social Stress Test (Kirschbaum et al., 1993; Kudielka et al., 2007), a standardized in-lab performance task designed to elicit moderate psychosocial stress. Typically, the participant is asked to prepare for 3 minutes, and then deliver a speech for 5 minutes and perform mental arithmetic for another 5 minutes, in front of an unresponsive audience, followed by a rest period (Kudielka et al., 2007). Salivary cortisol levels are measured concurrently at regular intervals, and can be tracked at resting, anticipatory, peak, and recovery times. Recent versions of the Trier Social Stress Test have looked beyond the individual and take the romantic partner into account (e.g. Ditzen et al., 2019; Engert et al., 2014; Engert et al., 2018). For example, a higher amount of intimacy (i.e. spontaneous physical contact) before and after the stress task was associated with attenuated cortisol increases and accelerated cortisol recovery (Ditzen et al., 2019). Other work suggests that individuals can also show 'empathic cortisol responses' while observing one's partner undergo the stress task (Engert et al., 2014), suggesting that couples may partake physiologically in each other's stressors. These findings dovetail with the results presented in Chapter 3, where salivary cortisol was found to co-vary with one's own emotional experiences, as well as those of one's partner (if one's partner was perceived to be sharing their feelings). The Trier Social Stress Task would be useful for presenting a standardized challenge to spouses, and could be combined with affect rating dials to examine cortisol-affect linkages. I would expect that one's negative affect ratings would correspond with one's own heightened salivary cortisol while participating in a stress task oneself, but also if watching one's partner go through a stress task.

5.2.8 Effect Size, Power, and Measurement Considerations

Overall effect sizes were approximated through a pseudo R-squared approach (Snijders & Bosker, 2012). Models explained a total of 3% to 54% of variance in their respective outcomes. Including interactions of interest reduced unexplained variability in the respective outcomes from 11% to 87%, relative to models that did not include interactions of interest. Small effect sizes are often expected and observed in naturalistic studies of daily life, relative to those obtained in controlled laboratory settings (Bolger et al., 2003). However, studies that use repeated daily life assessments in combination with longitudinal outcomes also suggest that these small effects can still accumulate into longer-term health consequences (e.g. Piazza et al., 2013). Hence, even small effect sizes obtained from naturalistic data could be meaningful.

Determining power in multilevel data is a complex issue, but simulation approaches suggest that multilevel models with at least 50 units at the upper level adequately estimate standard errors (Maas & Hox, 2005). The samples used in this dissertation included 84 to 119 couples (i.e. upper units), and thus are in line with this requirement. Multilevel models are generally best-powered to estimate effects at lower units, because there are generally more measurement points than individuals or couples (Bolger et al., 2012). Indeed, in this dissertation, I was able to use 4132 to 8842 repeated measures to examine within-person changes across Chapters 2 and 3. This dissertation focused on time-varying associations (i.e. lower units), given my conceptual interest in fluctuating emotional experiences. I was also conceptually interested in discrete emotional items that are particularly relevant for aging (e.g. happiness, sadness, contentment). However, discrete measures are generally less reliable than composite measures (e.g. positive and negative affect), and reliability has an inverse relationship with power. However, I was able to examine associations with discrete emotions, because I was well-powered especially to examine

associations at the ‘momentary’ or within-person level. Since I had many more measurement points than individuals, associations with discrete emotions and other variables of interest may have been more easily examined with within-person analyses, relative to between-person differences, for instance.

Structural equation modelling (used in Chapter 4) is generally a large sample technique, requiring a sample size of at least 100 participants to test complex models of between-person differences, depending on the number of indicators, factors, and intercorrelations (Savalei & Bentler, 2006; Wolf et al., 2013). Within-person differences can be modelled with a minimum of three repeated measures (Boker & Nesselroade, 2002; Singer & Willet, 2003). In this dissertation, within-person fluctuations in emotional experiences are modelled with up to 28 repeated measurements, but within-person changes in health indices could only be modelled with three annual assessments. The inclusion of additional annual assessment points would be needed to detect non-linear patterns of change (Singer & Willet, 2003). For example, non-linear changes across time have been found for marital quality in couples entering parenthood (Bradbury & Karney, 2004) and for emotional experiences across the lifespan (Carstensen et al., 2000). More than three assessment points would be needed to answer questions of whether associations between fluctuations in emotions and longer-term health are more or less pronounced depending on different challenges and points in time. The sample size in Chapter 4 (N = 119 couples) is consistent with minimal sample size requirements to detect between-person differences, but considering the complexity of the correlated growth curve models used, I cannot rule out that lack of power may have precluded detecting associations of interest. In an effort to maximize power, I used positive and negative affect composites in Chapter 4, rather than continuing to focus on discrete emotion items (because composite measures generally show greater reliability

than discrete items). Conceptually, an advantage of using composites was that it also allowed me to extend literature connecting broader positive and negative affect variability to health, with longitudinal data. While the findings in Chapter 4 suggest dyadic linkages between affect variability and longer-term changes in health, given power concerns, they may best be viewed as initial evidence requiring replication with larger samples and more assessment points.

5.3 Research Extensions

A strength of the current work is that it extends the scope of the affect-health literature to a dyadic context. I focused on the marital relationship due to the central role that spouses play in each other's daily lives, particularly in older age (Hoppmann & Gerstorf, 2016). However, this line of work would be well-extended by looking beyond heterosexual couples. For example, in a sample of middle-aged couples (aged 35 – 65 years) in same-sex or different-sex marriages, women were more strongly influenced by their spouse's psychological distress, regardless of whether their spouse was a man or woman (although the association was stronger for women married to a man; Behler et al., 2019). Hence, the degree to which the fluctuating emotional experiences of one's partner impact one's own health may depend on gendered patterns within the relationship. Further, it is reasonable to assume that the challenges faced by same-sex couples are different from those experienced by heterosexual couples, with potentially important consequences for aging trajectories (Zdaniuk & Smith, 2016).

A central proposition of this dissertation is that while the marital relationship can be an important resource, it can also introduce vulnerabilities. Perhaps this is especially true with the loss of a marital partner, whether by separation and divorce, or with the death of a spouse. Divorce rates in adults aged 50 years or more are increasing, although little is known about how divorce affects health in later life (Brown & Lin, 2012). Stress models of marriage suggests that

transitioning from marriage to separation or divorce is more highly related to changes in health, relative to marital status itself (Liu, 2012). Further, remarriage after divorce can introduce complicated stepfamily dynamics that correspond with increased risk of marital instability and stress-eliciting experiences (DeLongis & Zwicker, 2017; Stephenson & DeLongis, 2019).

Loss of a marital partner can also come about through the death of a spouse, and there is a relatively larger aging literature on widowhood than divorce. Widowhood is an extremely stressful life event in older age (Bonanno et al., 2002). Previous findings suggest that individuals show increases in affect reactivity to daily stress in times of elevated global stress (Sliwinski et al., 2009). Given that widowhood seems to result in increased lability in emotional experiences (Bisconti et al., 2006), I would expect that associations between fluctuating emotional experiences and health may be especially pronounced (at least immediately) following the loss of a spouse. However, physical and mental health trajectories following widowhood show substantial between-person heterogeneity, with maintained engagement with daily life activities and social relationships representing protective resources (Infurna & Luthar, 2017). Hence, the degree to which one is able to 'stabilize' following spousal death may depend partially on the availability and quality of other social resources beyond marriage. The experience of spouses before widowhood may also make a difference for adjustment, in that spousal intercorrelations in emotional experiences and health may continue after the death of a spouse – indeed, one's deceased partner's quality of life continues to predict one's own quality of life following bereavement (Bourassa et al., 2016).

A valuable extension of the research presented in this dissertation could be to longitudinally and repeatedly examine fluctuations in emotional experiences before, immediately after, and in the years following spousal loss. Taking such an approach would allow for the

identification of predictors and the time course of associations between health and emotional lability, as well as stability, in reaction to spousal loss (e.g. Bisconti et al., 2006). While the current line of research focuses on ongoing marital relationships, many older adults must navigate life without their spouse after many years of marriage, and a better understanding of how older adults can successfully adapt is needed.

5.4 Conclusions

While associations between emotional experiences and health are well-established (Pressman & Cohen, 2005; Watson, 1988), their dynamic and interpersonal context is less well understood (Butler, 2015). This dissertation examined time-varying and dyadic associations between emotional experiences and health, in the daily lives of older adult couples. Specifically, my findings suggest that fluctuations in happiness are linked with empathic accuracy among spouses (Chapter 2), while sadness and contentment co-vary with salivary cortisol (Chapter 3). Importantly, short-term fluctuations in positive and negative emotional experiences may also accumulate into longer-term health outcomes, for both spouses (Chapter 4). Taken together, this dissertation provides initial evidence for spousal links in emotional experiences as both a resource, as well as a vulnerability, in older adulthood, depending on the point in time under investigation.

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