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The Occurrence and Correlates of Emotional Interdependence in Romantic Relationships

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Abstract

Interdependence, including emotional interdependence, is widely considered to be a cornerstone of close relationships. Through frequent interactions, romantic partners are thought to continuously exchange, influence, and respond to one another's emotions, leading their feelings to become closely aligned over time. Although prior research has shown that such emotional interdependence can arise in couples, no research to date has comprehensively investigated its occurrence, degree, consistency and correlates. Across three different studies, we examined whether and to what extent couples indeed show interpersonal emotional connections (compared to pseudo-couples). Additionally, we investigated its consistency and moderating factors, by examining emotional interdependence across different types of emotions (negative vs. positive vs. emotional extremity), timescales (second-to-second vs. daily life), and situational contexts (supportive vs. conflictual), and by inspecting associations with indicators of relationship closeness (relationship longevity, cohabitation status, commitment, and closeness in terms of including the other in the self). The findings show limited evidence for emotional interdependence. The overall mean level of interdependence was significantly larger than that of randomly composed couples, but only a minority of the couples demonstrated emotional interdependence to a greater extent than these pseudo-couples. Moreover, the degree to which couples exhibited emotional interdependence showed little consistency across timescales and contexts, and was not clearly associated with

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relationship closeness. We discuss potential implications for the field of interpersonal emotion dynamics.

Keywords

interpersonal emotion dynamics; interdependence; close relationships; emotion; emotion transmission

Emotional interdependence and connectedness is seen as a core defining feature of close relationships by theorists (e.g., Berscheid, 1983; Butler, 2011; Schoebi & Randall, 2015, 2018), relationship therapists (e.g. Johnson, 2004), and laypeople (e.g., Huntsinger, Lun, Sinclair, & Clore, 2009a; 2009b). Nevertheless, the question remains whether this supposed central role of emotional interdependence is rooted in firm empirical evidence. Are the emotions and feelings of romantic partners indeed heavily intertwined, and does this intertwining play a key role in determining the closeness of a relationship? In the present manuscript, we report a systematic and comprehensive attempt to verify the existence and possible boundary conditions of emotional interdependence or dynamics in romantic couples, drawing on multiple methods and concepts from basic emotion dynamics research. In this way, we aim to provide an empirically informed window onto the emotional processes in intimate relationships, but also on current assumptions and approaches in the field of interpersonal emotion dynamics. Together, this work contributes to a better understanding of the intrinsic link between emotions and relationships, which are both central to and predict people's well-being and health (e.g., Sbarra & Coan, 2018).

Interdependence in Close Relationships

In relationship science, one of the most influential ideas has been that close relationships are characterized by interdependence (for reviews and overviews, see Finkel & Simpson, 2015; Finkel, Simpson, & Eastwick, 2017; Reis & Rusbult, 2004). The origins of this idea stem from interdependence theory, starting with the pioneering work of John Thibaut and Harold Kelley (1959) on social interactions. They emphasize the power that interactants have to shape each other's outcomes, which will guide their behavior during these interactions. This work was then extended to close relationships, focusing on the idea that in close, interdependent relationships, each behavior has consequences for the other, which will impact the behavior of the individuals (Kelley, 1979; Kelley et al., 1983). A close relationship was defined as "one of strong, frequent, and diverse interdependence that lasts over a considerable period of time" with each person's events -actions, thoughts, and emotions-being causally connected to the events -actions, thoughts, and emotions- in another person (Kelley et al., 1983).

Interdependence theory has inspired many other relationship theories, among them motivation-management theory (Murray & Holmes, 2009), the theory of the relational self (Andersen & Chen, 2002; Chen, Boucher, Andersen, & Saribay, 2013), self-expansion theory (Aron, Lewandowski, Mashek, & Aron, 2013), and transactive goal dynamics theory (Fitzsimons, Finkel, & vanDellen, 2015). These theories share the idea that close involvement of partners over time can result in a sort of relational, interdependent self

(Agnew, Van Lange, Rusbult, & Langston, 1998; Aron, Aron, Tudor, & Nelson, 1991; Chen, Boucher, & Tapias, 2006; Fitzsimons et al., 2015). Emotional, behavioral, motivational, and cognitive blending between partners occurs, and psychological boundaries between the self and the partner become blurred (Aron, Mashek, & Aron, 2004; Arriaga & Agnew, 2001; Finkel et al., 2017; Fitzsimons et al., 2015).

Emotional interdependence in close relationships: Theories

In the emotional realm, an affective connection would arise between partners, with partners' emotions and emotional well-being becoming increasingly dependent on their partners' behavior and emotional experiences (Arriaga & Agnew, 2001; Berscheid & Ammazzalorso, 2001; Butler, 2011, Schoebi & Randall, 2018). As partners become increasingly close and reliant on each other, they develop more and firmer expectations about each other's behavior (Berscheid, 1983; Berscheid & Ammazzalorso, 2001). These expectations not only aid partners in coordinating their behavior and plans, but also result in greater potential for disruptions and the transmission of emotion of one to the other (according to the emotion-in-relationship model). Relatedly, broader social psychological theories on emotion transmission, such as emotion contagion (Hatfield, Cacioppo, & Rapson, 1994), emotional assimilation (Fischer, Rotteveel, Evers, & Manstead, 2004), or mood contagion theories (Joiner & Katz, 1999), also posit that emotion transmission increases with the closeness of a relationship.

Several other theories of close relationships share the idea that interpersonal emotional linkages are a fundamental component of close relationships. For instance, the emotional convergence hypothesis suggests that people in a close relationship become more emotionally similar over time because this enhances coordination, understanding, and closeness between them (Anderson, Keltner, Tiedens, & Leach, 2004). Additionally, theories on co-regulation and interpersonal regulation focus on how close relationship partners' emotions regulate each other (Butler & Randall, 2013; Sbarra & Hazan, 2008), and multiple therapies built further on the idea that romantic partners show specific patterns of emotional exchanges during their interactions that are indicative for marital satisfaction (e.g., Gottman's therapies; EFT).

Finally, and more bottom-up, the domain of interpersonal emotion dynamics started exclusively focusing on how emotions between people interact with each other (Boiger & Mesquita, 2012; Butler, 2011; Butler, 2015; Fischer & Van Kleef, 2010; Kappas, 2013; Zaki & Williams, 2013). The influences of close relationship partners on each other's emotions are considered of special importance here, just because of the highly interdependent lives partners lead and the cardinal role of emotions in close relationships (Butler, 2011; Randall & Schoebi, 2015). The idea is that emotions between partners become linked across time, sometimes referred to as TIES (temporal interpersonal emotion systems; Butler, 2011), emotional connectedness (Schoebi & Randall, 2015; Randall & Schoebi, 2015), or emotional coordination or interdependence (Randall, Post, Reed, & Butler, 2013).

Empirical evidence for emotional interdependence in close relationships

Although the occurrence and moderators of emotional interdependence in close relationships is being increasingly studied, the existing empirical research is scattered and not well-integrated, and its findings provide a complex picture (Boiger & Mesquita, 2012; Butler, 2011; Butler, 2015; Fischer & Van Kleef, 2010; Kappas, 2013; Randall & Schoebi, 2015; Zaki & Williams, 2013). On the one hand, results from these studies suggest that emotional interconnections between romantic partners indeed can occur, especially for negative emotions (e.g., Larson & Almeida, 1999; Butler, 2011; Butner et al., 2007; Saxbe & Repetti, 2010) For instance, it has been comprehensively documented that negative emotions and stress caused by stressors such as work or exams can "spill over" to close relationship partners (for overviews, see Larson & Almeida, 1999; Westman, 2001). On the other hand, these studies also suggest substantial inter-couple differences in the degree that couples manifest such emotional interdependence (e.g., Randall, Corkery, Duggi, Kamble, & Butler, 2011; Randall & Schoebi, 2015; Schoebi, Wang, Ababkov, & Perrez, 2010). Recent studies in which emotional interdependence was assessed one couple at a time revealed that many couples, often the majority of the sample being studied, did not show convincing evidence for interpersonal emotional connections (Ferrer & Widaman, 2008; Madhyastha, Gottman, & Hamaker, 2011; Sels, Ceulemans, Bulteel, & Kuppens, 2016; Steele & Nesselroade, 2014). As most of the existing studies focused on one characteristic of interpersonal emotion dynamics (e.g., synchrony, emotion transmission, et cetera) for one (type of) emotion, on one timescale, and/or in one context; it is unclear how findings from these studies relate to each other and how these differences moderate the level of emotional interdependence observed in couples (Butler, 2011, 2015; Schoebi & Randall, 2015).

Findings of studies on individual differences that could moderate emotional interdependence have not provided a consistent story either. Both beneficial and negative relationship processes have been associated with increased emotional interdependence in couples (e.g., perceived collaboration, Berg, Wiebe, & Butner, 2011; cooperation, Randall, Post, Reed, & Butler, 2013; interpersonal sensitivity, Schoebi, 2008; insecure attachment, Butner et al., 2007; stress, Larson & Almeida, 1999; Neff & Karney, 2007; and relationship quality, Anderson, Keltner, & John, 2003; Gonzaga, Campos, & Bradbury, 2007; Saxbe & Repetti, 2010). Additionally, depending on the specific study, closeness of a relationship increased, decreased, or did not impact emotional interdependence in couples. For instance, the collectivistic values that couples endorsed have been positively related to emotional interdependence (Schoebi et al., 2010), whereas interdependent self-construals have not (Paukert, Petit, & Amacker, 2008). Moreover, experimental studies sometimes showed more emotion contagion of positive emotions in friends than in strangers (Kimura, Daibo, & Yogo, 2008), but found opposite results for negative emotions; a meta-analysis suggested more contagion of negative emotion between strangers than friends (Joiner & Katz, 1999).

Finally, with regards to empirical evidence for the emotional convergence theory, there is some evidence that relationship partners become more emotionally similar over time (Anderson et al., 2003), and that this predicts closeness and relationship stability (Anderson et al., 2003; Gonzaga, Campos, & Bradbury, 2007), but other studies did not replicate (Feng

& Baker, 1994; Gonzaga, Carter, & Buckwalter, 2010; Luo & Klohnen, 2005) and even contested these findings (Segrin, 2004, 2006).

All in all, a thorough consideration of empirical work on interpersonal emotion dynamics suggests that emotional interdependence might not be an intrinsic characteristic of close, romantic relationships, but instead may be a much more context-dependent characteristic (see also Timmons et al., 2016 & Butler, 2011 for comments on this topic). Whether and how different contexts -such as the valence of the context, the valence of the emotion under investigation, the specific dynamic characteristic looked at, or the timescale on which emotional interdependence is assessed- exactly shapes the extent of emotional interdependence observed in couples, is, however, not known.

Current studies

Given this state of affairs, we consider it crucial to undertake a comprehensive and systematic investigation to explicitly verify the existence and boundary conditions of emotional interdependence in romantic couples. Specifically, we thoroughly examined the occurrence, degree, consistency, and correlates of emotional interdependence in three different studies. Together, these studies addressed two main questions: (1) whether emotions between partners are indeed interconnected over time and what the extent of this interconnection is, and (2) to what extent emotional interdependence can be considered as a consistent and stable characteristic of the couple, or as emotion-, timescale- or context-dependent?

Study 1 involved a lab study in which 79 couples discussed several health-related topics and afterwards rated their momentary emotional experience second-by-second with a rating dial. This study allowed us to investigate the occurrence and extent of emotional interdependence during an actual interaction and a second-to-second timescale.

Study 2 relied on experience sampling methodology and involved 50 couples who reported on their emotions multiple times a day for a week using smartphones. This study enabled us to preliminarily investigate the occurrence and extent of emotional interdependence between partners in daily life.

Study 3 (n = 101 couples) combined the strengths of the previous two studies and consisted of a combination of laboratory and experience sampling methods. In the lab session, couples first had to talk about a negative relationship topic, which was meant to elicit a negative situational context, and then about a positive topic, meant to elicit a positive context. As in Study 1, the couples engaged in video-mediated recall and rated their momentary emotional experience on a second-by-second scale. Afterwards, they recorded their emotions in daily life using smartphones over the course of a week. This multi-method study enabled us to investigate whether the degree of interpersonal connections was consistent across timescales and situational contexts. Were the couples who exhibited more emotional interdependence in the lab (on a second-to-second basis) the same couples who exhibited more emotional interdependence in daily life? Similarly, were the couples who exhibited more emotional

interdependence during a negative interaction the same couples who exhibited more emotional interdependence during a positive interaction?

Capturing emotional interdependence

Emotional interdependence in its broadest sense incorporates any emotional linkage that would arise between romantic partners over time. We investigated a range of interpersonal emotion characteristics, including both linear and non-linear and more and less traditional approaches, to exhaustively capture such linkages.

First, we examined two linear interpersonal emotional characteristics that are traditionally studied in interpersonal emotion dynamics research, and that differ from each other in their time-dependency: emotional covariation and emotional susceptibility (Butler, 2011; Sels, Ceulemans, & Kuppens, 2017). Emotional covariation (sometimes referred to as emotional similarity, coregulation, or synchrony; Anderson et al., 2003; Papp et al., 2013; Saxbe & Repetti, 2010) captures the extent to which emotions of two partners fluctuate together across time (Butler, 2011). Emotional susceptibility (sometimes referred to as emotion transfer, transmission or crossover; Parkinson, 2011; Larson, & Almeida, 1999; Westman, 2011) captures the extent to which change in a person's emotion is predicted by a change in the emotion of their partner at the previous time point (Larson & Almeida, 1999). It explicitly captures the time-dependent, temporal component of emotional change, and is different for each partner (Larson & Almeida, 1999; Sels et al., 2016).

Second, we examined an interpersonal emotion dynamic characteristic that captures both linear and non-linear concurrent covariation between partners' emotions, or more general interdependence, by means of the distance correlation. This measure encompasses dependency between partners' emotions by looking at Euclidean distances between observations (Székely, Rizzo, & Bakirov, 2007). To our knowledge, this statistical measure has not been applied yet in interpersonal emotion dynamic research. It does, however, meet the emerging calls to also take into account non-linear dynamics in order to properly capture interpersonal emotional linkages (Butner, Amazeen, & Mulvey, 2005; Butler, 2017; Butner, Crenshaw, Munion, Wong, & Baucom, in press; Chow, Ferrer, & Nesselroade, 2007). Increasingly, emotions are considered to be dynamical systems, and one of the key characteristics of such dynamic systems is nonlinearity (Butler, 2017; Hollenstein, 2015; Lewis, 2000).

Third, in the lab interactions, we examined if partners' emotional cycles become coupled over time, referred to as coupling (Butner, Amazeen, & Mulvey, 2005; Butner, Diamond, & Hicks, 2007). The dynamic nature of emotions implies that they tend to follow cyclical, oscillatory patterns (Chow, Ram, Fujita, Boker, & Clore, 2005; Petterson, Boker, Watson, Clark, & Tellegen, 2013). Therefore, partners may exert influences on each other's emotional cycles and rates of change, which can be assessed by coupled oscillator models (Boker & Nesselroade, 2002; Boker, Deboeck, Edler, & Keel, 2010).[1]

[1]We only examined coupling in the lab interactions, because we did not have enough emotion observations and equal spacing between these observations in daily life (as we did not assess emotions overnight) to accurately estimate oscillatory cycles. We only examined

Emotional interdependence was assessed in terms of valence (hedonic tone, ranging from very negative to very positive) for the lab interactions (Study 1 and 3) and for positive and negative emotions separately in the daily life studies (Study 2 and 3). We also calculated emotional interdependence measures for emotional extremity, which captured change and influence between partners' emotions in general without imposing other restrictions. Specifically, this construct was developed to represent the extent to which the occurrence of any emotional experience in one partner is linked to any emotional experience in the other partner, regardless of its valence or the exact emotion that was occurring. In other words, is any greater emotional experience in one partner related to any greater emotional experience in the other partner? Table 1 summarizes the characteristics of emotional interdependence investigated in each study.

A benchmark to determine whether emotions between partners are linked across time

To better understand the meaning of the degree of detected emotional interdependence in couples, we compared the strength of true couples' interpersonal emotional connections to the strength of interpersonal emotional linkages between randomly paired individuals (see Madhyastha et al., 2011 for a similar approach). People can show interpersonal emotional linkages due to intrapersonal factors such as similar emotional cycles (e.g., across weeks) or similar environments (e.g., weather, societal events), but that do not result from interpersonal influence and thus actually are false positives (Butler, 2011; Coco & Dale, 2014; Madhyastha et al., 2011; Peters & Kashima, 2015).[2] First, we compared the mean emotional interdependence measures of all couples to the null distributions derived from randomly composed pseudo-couples. Second, we identified per couple, how many of them showed more emotional interdependence than what falls within the 95% boundaries of the distribution of emotional interdependence from pseudo-couples. In this way, we created a null benchmark to compare the level of observed emotional interdependence in real couples to pseudo-couples, both on the average and individual levels.

Moderators and consistency of emotional interdependence

In all studies, we also examined several key potential moderators of the degree of emotional interdependence. To select these moderators, we relied on Transactive Goal Dynamics Theory (Fitzsimons, Finkel, & vanDellen, 2015), which integrates several important relationship theories and principles (Finkel, Simpson, & Eastwick, 2017), and closely aligns with original interdependence theories (Kelley et al., 1979). This theory provides a framework to capture how couples' goals can become intertwined over time, and two partners start to form one self-regulating system. Different antecedents predict the degree to

coupling in the lab interactions, because we did not have enough emotion observations and equal spacing between these observations in daily life (as we did not assess emotions overnight) to accurately estimate oscillatory cycles.

[2]This method has been used to some extent in couple studies in the past, showing that the average degree of emotional similarity (Anderson et al, 2003; Gonzaga, Campos, & Bradbury, 2007) and physiological correspondence (Helm, Sbarra, & Ferrer, 2012) in real couples was significantly bigger than the degree of emotional similarity and physiological correspondence in randomly assigned couples. In other work, however, spousal emotional influence (between partners' observed affect) during an interaction was only slightly bigger than what was found when looking at pseudo-couples (Madhyastha et al., 2011).

which couples' goals become interdependent over time, such as opportunity and motivation. As for goals, we assumed that similar variables predict the opportunity and/or motivation to become more or less emotionally interdependent as well.

Opportunities are factors that allow and enable partners to become interdependent. We examined (1) amount of time spent together, (2) cohabitation status, and (3) relationship longevity as factors that could impact the opportunity to become interdependent, and thus the degree of emotional interdependence observed in couples.[3]

Amount of time spent together.

Emotional linkages between partners can appear due to different underlying processes. For instance, they can be caused by couples being emotionally similar (due to similar external circumstances, similar appraisals to events, et cetera) or they can reflect immediate influencing processes, such as through social appraisal, mimicry or conscious regulation efforts (e.g. Zaki & Williams, 2013). These mechanisms share the requirement that partners must be together, so that they can detect each other's emotions and actually exert an impact on each other. Because several processes that would result in interpersonal emotional linkages require interaction, we would expect partners that spend more time together to be more interdependent (Fitzsimons et al., 2015; Kelley et al., 1983).[4] When partners spend more time together, they have more opportunities to catch each other's emotions, to learn and communicate about each other's emotions, and so on.

Cohabitation status.

Because couples that cohabit generally spend more time together (Rhoades, Stanley, & Markman, 2009), we also expect cohabitation status to moderate the degree of observed emotional interdependence. Specifically, cohabiting couples would demonstrate more emotional interdependence than couples that (still) live apart.

Relationship longevity.

Finally, partners who have been coupled for longer have had more opportunities to become interdependent as well (Fitzsimons et al., 2015); therefore, relationship longevity was expected to be positively associated with the degree of visible emotional interdependence. However, it must be noted that existing empirical studies show no consistent association between relationship longevity and closeness (Berscheid, Snyder, & Omoto, 1989).

Beyond differences in the degree of opportunities, partners can be differently motivated to become emotionally interdependent with each other. We will investigate two individual differences that potentially moderate the motivation to become emotionally interdependent: (1) commitment and (2) closeness.[5] According to interdependence theorists, close involvement and structural dependence between partners results in a subjective experience of

[3]Although placed under opportunity, these factors might also affect the motivation to become interdependent.
[4]We also explicitly examined the degree of emotional interdependence for couples when they were together versus when they were apart. However, because this is partially redundant with the amount of time spent together, and poses several problems, these analyses are only reported in the supplementary materials S5. These analyses replicated the results of time spent together.
[5]Next to this, we also investigated the potential moderating effect of attachment anxiety, as it is a primary example of an individual difference that predicts increased reliance on and attention for the partner; which could also be expected to increase certain forms of

commitment and closeness (Agnew et al., 1998; Aron, Aron, & Smollan, 1992;Aron et al., 1991; Berscheid, Snyder, & Omoto, 1989; Kelley, Holmes, Kerr, Reis, & Rusbult, 2003; Rusbult & Buunk, 1993).

Commitment.

Commitment consists of three positively related but separate components: a cognitive, a conative, and an affective component (Arriaga & Agnew, 2001). The cognitive component represents a long-term orientation for the relationship, the conative component represents the intention to persist in the relationship, and the affective component represents psychological attachment to the relationship (i.e., the affective bond that develops between partners). Structural dependence, and this affective component in particular, implies that partners would become increasingly susceptible to emotions that are triggered by their partner, because each partner's circumstances are increasingly experienced as causally relevant to one's own circumstances (Arriaga & Agnew, 2001; Berscheid & Ammazzalorso, 2001).

Closeness.

As partners become increasingly committed to the relationship, their activities, goals, and interests become increasingly linked, and this linkage has been conceptualized as closeness (Kelley et al., 1983). Moreover, long term partners also come to think of their partner as part of the self and act as if some or all aspects of the partner are partially the individual's own (Agnew et al., 1998). A subjective sense of an interdependent self or closeness to a partner (Aron, Aron, & Smollan, 1992; Aron et al., 1991), would therefore also be expected to coincide with increased emotional interdependence.

In addition to these theoretically indicated moderating factors, we explored whether type of emotion, context, and time-scale mattered for the degree of emotional interdependence observed and if the degree of emotional interdependence in couples was consistent across these factors. Assessing the consistency of emotional interdependence is important, as most existing studies focus only on one particular context in which to investigate emotional interdependence. There are several reasons why emotional interdependence in couples may not generalize across different types of emotions, contexts, or time-scales. First, some processes and patterns may differ for *positive and negative emotions.* For instance, emotion transmission, or people catching a partner’s emotion whose source lies outside the relationship (e.g. caused by work), is primarily found for negative emotions and less so for positive ones (Larson & Almeida, 1999). Likewise, the specific interpersonal processes and mechanims underlying emotional interdependence are expected to depend on the specific context, such as *positive* versus *negative contexts.* In positive contexts, processes such as capitalization or the upregulation of each partner’s positive emotion might be particularly important (Gable & Reis, 2010) while in negative contexts, processes such as dyadic coping, soothing each other’s emotion, and negative affect-reciprocity might be more relevant (Butler, in press; Randall & Schoebi, in press, Zaki & Williams, 2013). Finally, different

emotional interdependence. However, because of an overburdening of the manuscript, and because it is not directly related to interdependence theories or derivatives, we decided to move hypothesis with regards to this variable and corresponding analyses to the supplementary materials S3.

processes might drive observed emotional linkages in couples depending on the *time scale* on which emotions are assessed (Hollenstein et al., 2013; Sels et al, 2018).

Study 1

In this study, couples discussed several health-related issues while being videotaped. After these conversations, each partner engaged in video-mediated recall. This means that they viewed a videotape of their conversation with their partner and while watching the video, they used a rating dial to provide a momentary self-report of their emotion during the interaction (Gottman & Levenson, 1985; Ruef & Levenson, 2007). We examined the existence and degree of emotional interdependence, in terms of concurrent and temporal linkages and coupling, and we examined potential associations with relationship longevity, and commitment.

Method

Participants

Couples were recruited by advertisements on Craigslist and electronic mailing lists of the local university (University of Arizona), by flyers that were posted in the community, and by word of mouth. They were recruited in the context of a larger study focusing on close relationships, eating, and emotions (Butler & Bernard, in press; Fonseca, Koyama, & Butler, 2018). In total, 79 couples participated. All couples were cohabiting, and the mean age was 27 years (*SD* = 9 years, min =18 years, max = 69 years). Sixteen percent of these couples were married, and couples had been together for 2 years on average (*SD* = 1 year and 4 months, min = 1 month, max = 5.5 years). A sensitivity analysis revealed that, given a sample size of 79 and a power of .80, between-person correlations had to be higher than |.22| to be detected by two-sided significance tests (.05), corresponding to a small to medium effect size[6].

Procedure

The study consisted of a baseline questionnaire, a laboratory session, a diary portion, and several interviews. Here, only data from the baseline questionnaire and parts of the laboratory session were used (the full questionnaires can be found in supplementary materials SI). Participants first filled in an online questionnaire that assessed relevant demographic and relationship information, including questions about relationship longevity, and commitment level. Next, a dyadic interaction paradigm was conducted, similar to those often used in couple studies (e.g., Cohan and Bradbury, 1997; Gottman, Coan, Carrere, & Swanson, 1998; Roberts, Tsai, & Coan, 2007; Roberts & Greenberg, 2002). Couples came into the laboratory and were asked, among other tasks, to converse about five topics. These topics were (1) the importance of a healthy lifestyle, (2) how the partners hindered, and (3)

[6]The sample size had not been determined by an a-priori power analysis for any of the studies, so we conducted sensitivity analyses to get a sense of the effects we are able to find with our samples. In this study, this gives an indication of how large an effect has to be before it can be detected with a sample size of 50, with an α (two-sided) = .05, and power = .80. We did not conduct a post-hoc power analysis because of the problems associated with this approach (Hoenig & Heisey, 2001; Levine & Hensom, 2001). In a post-hoc power analysis, you calculate the power, given a certain alpha, sample size, and effect size. This is a direct function of the observed p-value. In a sensitivity analysis, you calculate the effect size you are able to find, given a certain alpha, power, and sample size

helped each other in maintaining a healthy lifestyle, (4) what they would like to change in each other, and in what domain and (5) how they could obtain more support from each other. They were given 5 minutes to discuss each topic, but if they finished sooner, they could move to the next topic. On average, the whole sequence of conversations lasted for 16 minutes, and couples talked for a minimum of 7 and a maximum of 23 minutes. Following these conversations, participants were asked to hold each other's hands for 3 minutes. Next, they watched recordings of the conversations and engaged in video-mediated-recall in which they used a rating dial to indicate on a continuous basis how they had felt during the conversations.

Materials

Relationship longevity.—In the online questionnaire, participants were asked to indicate the total number of months that they and their partner had been in a romantic relationship together. Both partners' responses on this item were averaged ($r = .99$).

Commitment.—To assess commitment towards their romantic relationship, we used the 7-item commitment subscale of the Investment Model Scale (Rusbult, Martz, & Agnew, 1998). Participants responded to statements as "I want our relationship to last forever" by rating each item on a 9-point scale, ranging from "totally disagree" to "totally agree". Cronbach's alpha equaled .76 in the sample.

Laboratory emotion experience.—During the lab session, participants viewed recordings of their conversations and used a rating dial to continuously report their emotion during the conversation, ranging from positive to negative (Ruef & Levenson, 2007). This rating resulted in scores of each participant's self-reported emotional experience during the interaction in terms of valence (going from 0 to 5) on a two-second basis. Additionally, we derived measures for emotional extremity, representing how much a person's emotional experience deviated from his/her overall emotional experience (irrespective of the direction of deviation). To this end, we calculated each person's absolute standardized emotional experience.

Analyses

For a more elaborate explanation of the applied statistical approaches, we refer interested readers to supplementary materials S2.

Concurrent linkages between partners.

For each couple, we calculated the Pearson and the distance correlation between the partners' emotional experiences throughout the course of their interaction. While the Pearson correlation captured linear concurrent linkages, the distance correlation captured both linear and non-linear associations or more general interdependence (Szekely, Rizzo, & Bakirov, 2008; Zhou, 2014). Note that values for distance correlations range from 0 to 1, with 0 implying non-independence and 1 indicating perfect dependence. Similar Pearson and distance correlations were calculated for partners' emotional extremity, resulting in four concurrent linkage measures for each couple in total.

Temporal linkages between partners.

Per individual, we calculated the Pearson correlation between their emotional experience and their partner's previous emotional experience, controlling for own previous emotional experience. To decide on the best lag to use for previous emotional experience, we tested which lag had on average the largest predictive value for people's current emotion (controlling for people's own emotion at the same lag), going from 1 to 100. This way, we maximized the chance of observing emotional interdependence in the form of temporal linkages in couples. Based on this examination, we selected lag 8, or the emotional experience that occurred 16 seconds before the current emotion as the previous emotional experience. We calculated each participant's susceptibility for their partner's emotional extremity in a similar way.

Coupling.

Coupling parameters were estimated by coupled linear oscillator models, which rely on derivatives. We used the Rties package developed by Emily Butler (https://github.com/ebmtnprof/rties) that uses the local linear approximation for estimating coupled linear oscillator models for each couple separately (Boker, Deboeck, Edler, & Keel, 2010; Boker & Nesselroade, 2002). For each couple, we calculated the fit of the coupled oscillator model, describing the relative ability of each model to account for variance. This score thus indicates to what extent the partners' emotions were coupled over time. We then calculated the difference with the R^2 of an uncoupled model (i.e., a linear oscillator model without the coupling parameters). A positive R^2 difference for a certain couple indicates a better fit for the coupled-oscillator model, and thus evidence for coupling.

Permutation testing.

We compared the degree of observed emotional linkage in our sample to a benchmark derived from randomly paired individuals. To this end, we constructed new sampling distributions by generating pseudo-couples through reshuffling couple membership (n = 12324, Good, 2013; Higgins, 2003).

We always derived two baseline distributions to test the significance of each emotional interdependence measure: one for the mean level and another for the individual level. To generate the baseline distribution for the mean, we reshuffled the couple membership 5000 times and computed the mean emotional interdependence measure each time. We then compared the mean emotional interdependence measure of the real couples to the distribution of the mean values from the pseudo-couples, with *p*-values and thus probabilities lower than .05 being considered significant.

To derive the baseline distribution needed for the significance test at the individual level, we computed each emotional interdependence measure for all possible pseudo-couples. Given that the standard significance level is .05, we compared each interdependence measure for each couple to the 95% boundaries of this distribution. Only those couples who exceeded these boundaries were declared to have exhibited more emotional interdependence than what is expected by chance. Because partners can also show negative linear covariation or susceptibility, two-sided tests were conducted for the Pearson (concurrent and cross-lagged)

correlations. For the distance correlations and coupling indicators, one-sided tests were conducted.

Results

Are emotions between partners interconnected over time?

Concurrent linkages between partners.—On average, couples exhibited more concurrent linear and non-linear covariation in their emotional experience and in their emotional extremity than pseudo-couples (as evident in permutation tests for the means and positive mean values, see Table 2). In terms of effect sizes, the Pearson correlations showed that 3.5 to 5.5% of the variance in partners' emotions was shared, corresponding to small to moderate effect sizes. Partners' emotions were, on average, dependent on each other and tended to fluctuate together during the interaction. However, this was not the case for every couple: some couples' emotions fluctuated in opposite directions (as illustrated by the negative minimum of the Pearson correlation) and some couples' emotions were independent (as illustrated by a minimum close to zero for the distance correlation).

For the permutation tests at the individual level, permuted couples were expected to have lower interdependence values than real couples because the lengths of the total conversations were not equal across couples (the couples could switch to a next topic when they were finished with a topic within 5 minutes). Still, these tests revealed that less than half of the couples showed substantially more emotional linear and non-linear covariation than pseudo-couples. Specifically, 14 to 38 percent demonstrated substantial emotional covariation, depending on the specific emotional interdependence measure under investigation (see Table 2 for exact numbers).

Temporal linkages between partners.—Although the effect sizes were much smaller than for concurrent linkages, the average emotional susceptibility in real couples was substantially greater than in pseudo-couples (except for men's emotional susceptibility for their partner's emotional extremity, see Table 2). An increase in one partner's emotion tended to predict an increase in the other partner's emotion, and a decrease predicted a decrease. However, per individual permutation tests revealed that, in total, only 4 to 8 percent of the participants exceeded the boundaries of pseudo-couples for temporal linkages in their emotion. Although the majority of these participants showed susceptibility in the positive direction, meaning that their emotion changed in the same direction as their partner (e.g. an increase following an increase), some showed substantial evidence for a reversed pattern, with an increase following a decrease in their partners' emotions.

Coupling.—Although coupled-oscillator models led to an improvement in fit, this average improvement was not significantly different from that of pseudo-couples (as shown by permutation test for the means, see Table 2). In terms of effect sizes, only 2 to 5 percent of the variance in each partner's emotion was shared. Additionally, per couple permutation tests showed that only 5 percent of the couples demonstrated substantial coupling in their emotional experience or extremity.

Moderating factors of emotional interdependence.[7]

Relationship characteristics.—We investigated if the degree of emotional interdependence in couples in terms of concurrent and temporal linkages and coupling was associated with relationship characteristics by nonparametric correlation tests. In case that one of the involved variables was at the individual level, we took into account the effect of gender by computing semi-partial correlations. Because we tested for two moderators, we corrected for this by applying a Bonferroni correction, dividing α by 2, with $p < .025$ being significant.

The degree of emotional interdependence observed in couples was not associated with how long they had been in a relationship or with partners' commitment levels (Table 3).

Discussion

During a face-to-face interaction, couples on average demonstrated significantly stronger concurrent and (for the most part) temporal linkages in their emotional experience and extremity than pseudo-couples (with the effect sizes for temporal linkages being more than three times as small as the effect sizes for concurrent linkages). On average, partners did not demonstrate stronger evidence for coupling in their emotional experience or extremity than pseudo-couples.

Examining couples individually, however, revealed that less than half of the couples demonstrated substantially more emotional interdependence than pseudo-couples. Specifically, percentages varied from 2 percent (for coupling in emotional extremity) to 44 percent (for dependency in emotional experience as assessed by distance correlations). Additionally, although clearly a minority, there were couples who demonstrated negative patterns, with increases in one partner's emotion going together with or preceding decreases in the other one's emotion. The degree of emotional interdependence exhibited by couples was not associated with relationship longevity or commitment.

It was surprising that in a standardized environment, in which partner influences could not be overridden by variations in external circumstances and emotions were elicited by the partner him or herself, less than half of the couples exceeded the boundaries of the amount of emotional interdependence likely to be found in pseudo-couples. The relatively high observed correlations between people's emotions in pseudo-couples indicate that qualities inherent to an interaction, such as the general course of one-on-one conversations on similar topics, can result in large apparent linkages.

Study 2

Study 2 consisted of an experience sampling study (ESM study) with 50 romantic partners, in which partners simultaneously reported on their emotions, cognitions, and perceptions 10 times a day for a week. Emotions of both romantic partners were thus sampled in an

[7]For all individual-level moderating variables and emotional interdependence measures (temporal linkages), we also conducted dyadic models, taking into account that partners were part of a couple. As these results overall replicated the results of the correlational tests, and overburdened the manuscript, they were omitted.

intensive longitudinal fashion, enabling us to investigate (1) the existence and extent of emotional interdependence that occurs in daily life across a week, (2) the consistency of emotional interdependence across emotion type, (3) and potential moderation by variables that would affect the opportunity or motivation to become emotionally interdependent (herein, amount of time spent together, cohabitation status, and relationship longevity).

This study is a preliminary test of these hypotheses, which are more elaborately tested in a larger sample in Study 3, and is a secondary analysis of existing data. In Sels et al. (2016), we used data from this study for the first time to present a new way to examine temporal patterns of emotional interdependence in couples during daily life. That analysis captured the overall level of emotional influence in each couple, or the extent to which both partners were emotionally influenced, and emotionally influenced each other. Surprisingly, with this approach, we found that the majority of couples did not demonstrate strong signs of emotional interdependence. We also investigated relations with well-being indicators, finding some, but no clear associations. Here, we carefully re-analyzed the data in a more comprehensive manner (investigating multiple interpersonal emotion dynamic characteristics) as a baseline for comparison to the higher-powered Study 3.

Method

Participants

Fifty heterosexual couples (100 individuals) participated in a study of emotions in romantic relationships (see Dejonckheere et al, 2019; Erbas et al, 2015; Sels et al., 2016; Sels et al, 2019). These couples were recruited by flyers and ads that were distributed in public places and community and relationship therapy centers, and by social media.[8]

Participants were on average 28 years (*SD* = 11 years), ranging from 18 to 70 years, and couples had been together on average for 6 years (*SD* = 9 years). Twenty-eight couples were cohabiting, of whom 10 were married, and 22 couples were not (yet) living together. Each couple received 80 euros upon participation, or 40 euros per individual. A sensitivity analysis revealed that for this sample size, between-person correlations had to be larger than |.28| to be detected, which corresponds to a medium effect size.

Procedure

Couples were informed about the study at a group session and were instructed about the experience sampling protocol, how to work with the smartphone, and how to interpret the smartphone questions in a standardized manner. After these instructions, participants completed a battery of questionnaires, including questions about their relationship duration and cohabitation status (these questionnaires can be found in Supplementary materials S1). Next, each partner received a smartphone and practiced with a short demonstration, after which the experience sampling part started. Participants were beeped 10 times a day for one

[8]From the 161 couples who responded, we selected the final sample so that we would obtain sufficient variability on the variables age, relationship duration, and cohabitation status. Specifically, the interested couples were divided in different groups according to age (18-25, 26-40, and 41+), relationship duration (less than 6 months, more than 6 months) and cohabitation status (living apart, living together, and married). Next, a stratified sample of 50 couples was drawn. It must be noted that not every category had an equal amount of candidate couples.

week and answered questions about their emotions, behaviors, and perceptions (see supplementary materials S1 for all variables assessed). Partners were explicitly asked not to communicate with each other about the questions and their answers. Beeps occurred between 10 AM and 10 PM following a stratified random interval scheme, on average being separated by 1 hour and 12 minutes (*SD* = 29 minutes and 2 seconds), ranging from 30 minutes to 5 hours and 20 minutes. The smartphones were programmed such that both partners were beeped simultaneously, but the order of the questions was randomized per partner to avoid partners comparing responses. Compliance was high, with 92.03 % of responses completed.

Materials

Relationship longevity.—In the battery of questionnaires that participants filled in before starting the ESM-part, they were asked to indicate how long they and their partner had been together (by indicating the exact amount of years and months). Additionally, participants were asked how long they had known their partner, as a less stringent form of relationship longevity. The scores for these two items were averaged (r = .96). Additionally, answers of both partners were averaged to obtain a dyad-level variable (r = 1.00 for romantic relationship duration, r = .99 for total duration of relationship, and α = .99 for all 4 items).

Emotion in daily life.—At each assessment, participants were asked how relaxed, happy, satisfied, cheerful, anxious, angry, depressed and sad they felt at that moment on a slider scale going from not at all (0) to very much (100). These emotions were selected based on the circumplex model of affect (Barrett & Russell, 1998; Russell, 1980) A more elaborate explanation can be found in supplementary materials S4.

To create a positive emotion measure (PE), the answers to relaxed, happy, satisfied and cheerful were averaged (item-level reliability = .81, person-level reliability = .98[9]; Nezlek, 2012). We did the same to construct a negative emotion measurement with anxious, angry, depressed and sad (NE) (item-level reliability = .73, person-level reliability = .98). To capture emotional extremity (EE), we took several steps. First, we standardized all (eight) emotion variables within each participant. These transformed variables represented the deviation for each emotion relative to the person's specific mean for that emotion. Next, we calculated the absolute value of each standardized variable, so that the direction of the deviation did not matter. Then, we conducted a maximization approach, selecting the emotion that deviated most from its personal mean at each beep. In this way, we captured the most extreme emotional experience occurring in each person at each moment for each partner.

Interaction between partners.—At each report, participants indicated if they were together with their partner at that moment (*no* = 0, *yes* = 1). Couples were considered to have been together when one of the partners indicated "yes." Partners agreed that they were together or not in 96% of the cases (2917 out of 3044 occasions). Participants also indicated

[9]Reliability was calculated following multilevel recommendations. The between-person reliability indicates the reliability between people's average responses on items. The within-person reliability indicates how consistently items change together across time within persons.

if they had been in contact with their partner since the last assessment (recoded into *no* = 0, *yes* = 1), and again it was sufficient that one of the partners indicated "yes." Partners agreed in 87% of the occasions. We told participants that contact not only implied physical presence, but also calls, texts, chats, or any other form of communication with their partner.

Amount of time spent together.—Both partners' reports were used to calculate the amount of time that partners spent together during the experience sampling week. Specifically, we calculated the total amount of beeps on which each partner reported to be together with their partner at the moment beeped and the total number of beeps they filled out during the complete week. We then divided the average number of beeps on which both partners reported being together by the average total number of beeps they filled out. Participants were together during 39% of the beeps (*SD* = 18.5) or on average in 25 of the 63 cases.

Analyses

Concurrent linkages between partners.

We calculated Pearson and distance correlations for males' and females' NE, males' and females' PE, and males' and females' EE. These computations resulted in six concurrent linear and non-linear measures for emotional interdependence (n = 50 for each).[10]

Temporal linkages between partners.—For each individual, we calculated the Pearson correlation between that person's emotion at a given reporting time and the partner's emotion at the previous time, controlling for own emotion at the previous time, resulting in partial cross-lagged correlations. We did this for PE, NE, and EE separately, creating a measure for susceptibility for PE, NE, and EE (n = 100, or 50 for men and women separately).

Interaction between partners.—For our main analyses, we filtered those moments in which partners reported being together or having been in contact with their partner since the last report to increase the chance of finding emotional interdependence (for temporal linkages, this means that for the current emotion, the partners reported being together or having been in contact since the last report). Our decision was based on several arguments. First, interaction between partners is a precondition for many processes that can result in interpersonal emotional linkages (e.g., emotion contagion or co-regulation) but at the same time these processes can occur through channels other than physical proximity. Second, adding the moments in which partners had been in contact since the previous report resulted in many more time points for each couple (*M* = 49, *SD* = 9, min = 29, max = 67) than only including the moments in which partners were together (*M* = 25, *SD* = 13, min = 4, max = 65), allowing more reliable estimates of emotional interdependence. We do, however,

[10]In this way, we did not control for linkages due to similar autocorrelations (Butler, 2011). However, we also ran all analyses for emotional interdependence by first regressing each person's emotion on his/her emotion at the previous time point, and then used the correlations of the partners' residuals, thus explicitly taking into account autocorrelations. As these analyses provided similar results, we report the regular correlations in the main text for parsimony.

compare results of analyses including only the moments in which partners were together versus not together in the supplementary materials S5.

Results

Are emotions between partners interconnected over time?

Concurrent linkages between partners.—On average, couples showed more linear and nonlinear covariation in their emotions than pseudo-couples (Table 4). Their emotions tended to fluctuate together and were dependent on each other. The sizes of the Pearson correlations indicate that 4 to 6 percent of the variance in each partner's emotion was shared, corresponding to small to moderate effect sizes. However, there were substantial differences among couples.

Permutation tests for each couple revealed that only a minority of the couples exceeded the boundaries of both linear and non-linear covariation in NE, PE, and EE (Table 4). Depending on the type of emotion and covariation under investigation, 26 to 36 percent of the couples were substantially characterized by emotional interdependence. All the couples that exceeded the boundaries for the Pearson correlations showed positive covariation, with an increase (or decrease) in one partner's emotion going together with an increase (or decrease) in the other partner.

Temporal linkages between partners.—Overall, the sizes of temporal linkages in real couples did not differ substantially from pseudo-couples (Table 4). In terms of effect sizes, explained variance ranged from 0 to 0.24 percent, thus being very small. Again, there was a lot of inter-couple variation in the extent and the direction of these temporal linkages.

When we conducted permutation tests, only 4 to 8 % of all individuals revealed substantial susceptibility for their partners' emotions. Further, some of these individuals showed substantial negative susceptibility, meaning that their partners' previous emotion negatively predicted their emotion at a following time point (sometimes also called an anti-phase pattern; Randall et al., 2013; Reed, Randall, Post, & Butler, 2013).

Type of emotion.—To investigate if the observed emotional interdependence in couples was emotion-specific or generalized across NE, PE, and EE, we examined consistency in the degree of emotional interdependence in couples across the different types of emotions. The specific analyses and results can be found in the supplementary materials S6, showing that the extent of concurrent linkages was consistent across different types of emotion, but that this was less the case for temporal linkages. Participants who were more susceptible to their partners' negative emotions were also more susceptible to their partners' emotional extremity, but there were no effects between negative and positive emotions, or positive emotions and emotional extremity.

Moderators of emotional interdependence

We investigated the potentially moderating impact of amount of time spent together and relationship longevity on emotional interdependence by nonparametric correlation tests. We took gender into account each time an individual-level variable was involved, and corrected

for multiple testing by setting the significance level at .017 (as we looked at 3 moderators). The impact of cohabitation status was investigated by Welch's t-tests, again considering values below .017 as significant[11]. The exact results can be found in Table 5. Time spent together by partners was positively associated with how much general dependence these partners showed in their positive emotions, but not convincingly with the extent of their concurrent linear linkages (being only significant without correction) or with their temporal linkages. The amount of time spent together also did not matter for the degree of observed emotional interdependence in negative emotions or emotional extremity. Relationship longevity was not associated with the degree of any emotional interdependence measure. Couples who cohabited demonstrated more dependence than non-cohabiting couples in their EE in terms of distance correlations (and trended in that direction for Pearson correlations), but not in their NE or PE, and there were no differences for temporal linkages.

Discussion

On average, couples showed emotional interdependence that was significantly different from pseudo-couples for concurrent linkages, but not for temporal linkages in daily life. Specifically, couples demonstrated positive concurrent linear and non-linear covariation in their negative emotions, positive emotions, and emotional extremity. When couples were inspected individually, 26 to 36% evidenced substantial emotional covariation, and 4 to 9% of the partners exceeded the amount of susceptibility that was found in pseudo-couples. The number of couples that exceeded the 95% confidence interval for emotional susceptibility was especially low considering that even when the null hypothesis is true (and thus that there is no more emotional interdependence than observed in pseudo-couples), we would expect 5% of the cases to exceed this value. Additionally, couples differed tremendously in the size and direction of emotional interdependence. In the case of temporal linkages, some individuals even showed evidence for negative patterns, or an increase in their emotions after a prior decrease in their partners' equivalent emotions. Emotional interdependence seemed consistent across different types of emotions for concurrent linkages, but less so for temporal linkages.

Further, emotional interdependence seemed largely unaffected by potential moderators of the opportunity or motivation for emotional interdependence. The amount of time that partners spent together was positively related to the extent to which positive emotions were dependent on each other, but not to the extent of covariation in negative emotions or emotional extremity, or temporal linkages. Similarly, couples who cohabited, demonstrated more dependence in emotional extremity than non-cohabiting couples, but this was not the case for negative or positive emotions or for any of the temporal linkages. Finally, relationship longevity was not associated with the degree of observed emotional interdependence.

We recognize that the lack of observed emotional interdependence in our couples could have been due to specific characteristics of the study, such as the small sample size and the fact that half of the couples lived apart (as both cohabitation status and time spent together did

[11]These were preferred over independent sample t-tests because sample sizes were unequal

show some effects on the degree of observed emotional interdependence). However, it is noteworthy that the second-to-second measure to assess emotional interdependence in terms of concurrent and temporal linkages during a face-to-face interaction (Study 1) revealed surprisingly similar results as these daily life measurements of emotional interdependence. The percentages of couples who exhibited emotional interdependence in the forms of concurrent and temporal linkages closely matched each other, and in both studies no clear relationships with closeness indicators were observed.

Study 3

In Study 3, we aimed to extend the findings from Studies 1 and 2 in a number of ways. First, Study 3 combined both methods, with a dyadic interaction lab session and an experience sampling part. In this way, we could investigate whether our results from both prior studies replicated in an independent, larger sample (n = 101), as well as allowed us to examine if the degree of emotional interdependence in couples was consistent across timescales and across a lab versus daily life comparison. Second, the lab session was set up differently than in Study 1. During the lab session, couples were asked to engage in two different conversations meant to elicit a negative and a positive context. By doing this, we could investigate if the degree of emotional interdependence evident in couples was consistent across situational contexts, specifically across negative and positive situations. Additionally, each couple was required to talk for the same amount of time (10 minutes for each conversation), whereas in Study 1 the final length of the interaction differed substantially depending on the specific couple. Third, the experience sampling method resembled Study 2, but couples were now beeped at times where they would be more likely to be together, including weekday evenings and all day on weekends. Finally, Study 3 allowed us to further examine the correlates of emotional interdependence, specifically time spent together, relationship longevity, commitment, and including the other in the self (Aron et al., 1992).

Method

Participants

One hundred and one heterosexual couples (or 202 individuals) participated in the study (Dejonckheere et al, 2019; Sels et al., 2019; Sels et al, 2018), having been recruited through social media, and flyers and ads distributed in public places. The age of participants ranged from 18 to 53 years old (M = 26.04, SD = 5.27). On average, couples had been together for 4.5 years (SD = 2.80), but relationship length varied from 7 months to 21 years. The majority of the couples (96) was cohabiting, with a few of them being married (7), and only 5 couples living separately. Five couples had children together at the start of the study. Upon completion of the study, couples were paid 100 euros. A sensitivity analysis revealed that the size of a between-person correlation had to be larger than |.20|, given a sample of 101, a power of .80, and a two-sided α of .05. This corresponds to a small to medium effect size.

Procedure

This study consisted of several different parts: a pre-lab assessment, an interaction lab part in which couples discussed several topics, and an experience sampling part (materials can be

found in supplementary materials S1). For the first part, both partners of each couple first filled in a pre-lab questionnaire online that asked about relevant individual and relational factors. For the purpose of the present study, only the questionnaires assessing indicators of interdependence, and specifically, relationship longevity, commitment, and inclusion of the other in the self, are reported here.

Next, each couple visited the lab and was asked to discuss three topics, which were videotaped with their consent. The topics of the conversations were, in the following order: events of the previous day (neutral topic), and their partner's most annoying (negative, conflictual context) and the most valuable (positive, intimate context) characteristic. The discussion of the neutral topic only took two minutes and was done to make the couples accustomed to the lab setting. The discussion of each partner's most annoying characteristic took 10 minutes in total, and was meant to elicit a negative, conflictual context that was relevant for both partners and their relationship. The discussion of each partner's most valuable characteristic took 10 minutes as well, and was meant to elicit a positive, intimate context that was relevant for both partners and their relationship. Before these conversations, participants filled in several questions in separate rooms, including questions about the partner characteristic (e.g. a description) and about concomitant appraisals. They then returned to the common room, and the conversation topic was initiated by a research facilitator, who gave some starting points to start the conversation (e.g., "you can start by describing what you have written about the characteristic, what exactly bothers you, why .."), and asked the couples to keep the conversation as natural as possible. To facilitate having a natural conversation, partners were allowed to choose who would begin the conversation, and when they would switch to the characteristic described by the other partner. Often, the discussion of their characteristics became blurred because both partners had chosen related (opposite) characteristics.

After each conversation, participants went back to their separate rooms, and filled in a questionnaire that assessed their emotions, perceptions, and behaviors during the conversations. Next, participants were asked to view recordings of their conversations and engaged in video-mediated recall. While viewing the videos, participants used a joystick to give a continuous report of their emotion during the conversation.

Finally, both partners received a smartphone and instructions, and the experience sampling part started in which the couples were simultaneously asked several times a day about their feelings and experiences for one week. Specifically, participants were beeped 6 times a day during weekdays, from 17 PM until 22 PM. On weekends, participants were assessed 14 times a day, ranging from 10 AM until 22 PM. These time spans were chosen based on the expectation that partners are likely to spend time together during these hours (in Belgium, the 9 to 5 working schedule from Monday to Friday is still the norm; Glorieux, Heyman, & Moens, 2007). Each time span was divided in equal intervals, with each signal being programmed randomly in each interval. On average, couples received 62 beeps (SD = 4, Min = 47, Max = 72), and compliance was high (93 %).

Materials

Relationship longevity.—In the online questionnaire, participants were asked how long they and their partner had been together, in years and months. The average of both partners' response was used ($r = 1.00$).

Commitment.—To assess commitment towards their romantic relationship, we used the 7-item commitment subscale of the Investment Model Scale (Rusbult, Martz, & Agnew, 1998). Chronbach's alpha equaled .81 in this study.

Closeness.—The Inclusion of Other in the Self scale (or IOS-scale) was used as a measure of closeness (Aron et al., 1992). In this single item scale, participants are shown seven pictures simultaneously and have to select the picture that best describes their relationship. Each picture is a Venn-like diagram with a varying degree of overlap between the two circles, and the degree of overlap progresses linearly with each figure. In this way, we obtained a rating for each participant's subjective sense of closeness.

Emotion in daily life.—At each sampling moment, participants were asked how angry, sad, anxious, lonely, happy, and relaxed they felt, scoring every emotion on a sliding scale from *not at all* (0) to *very much* (100). Responses to the emotions angry, sad, anxious and lonely were averaged to create a negative emotion measure (item-level reliability = .63, person-level reliability = .97), and responses to the emotions happy and relaxed were averaged to create a positive emotion measure (item-level reliability =.76, person-level reliability = .96). To assess emotional extremity, we used a similar approach as in Study 2.[12] Again, we will refer to negative emotions as NE, positive emotions as PE, and emotional extremity as EE.

Interaction between partners.—Participants indicated during each assessment if they were together with their partner at that moment (*no* = 0, *yes* = 1). If one of the partners indicated "yes", participants were considered to be together. Partners agreed in 96% of the cases. Participants also indicated if they had been in contact with their partner, with the available response options distinguishing between "no," "yes, we have texted/been chatting," "yes, we have called," "yes, we have seen each other."

Amount of time spent together.—This was calculated in a similar manner as in Study 2. We divided the average number of beeps on which both partners reported to be together by the average of the total number of beeps they filled out.

Laboratory emotion experience.—During the video-mediated task, while viewing the videos, participants used a joystick to give a continuous report of their emotion during the conversation. They could monitor the meaning of their movement on the computer screen, by a mark that was placed on a scale that was visible under the video. The left boundary of this scale was anchored as very negative and showed a red background which turned into a green background when going towards the right, with the right boundary being anchored as

[12]Note that the low within-person reliabilities for negative emotions suggest that the specific negative emotion items did not consistently fluctuate together across time within persons, emphasizing the value of our emotional extremity measure.

very positive. Prior to the video-mediated recall task, participants received instructions and were given a short demonstration to practice the specific movements and the meaning of these movements. This rating dial task provided us with each partner's self-reported emotional experience (in terms of valence, from −1 to 1) during each interaction on a second-to-second basis, and each partner's emotional extremity. For the latter, we calculated the absolute standardized versions of emotional experience for the negative and for the positive topic.

Analyses

Daily life

Due to various practical issues, not all couples ended up participating in the ESM-part of the study. For this part, we had complete data for 94 couples or 188 participants. To increase the chance of finding emotional interdependence in daily life, we selected only the moments in which partners reported that they were together with their partner or that they had seen their partner since the previous report. Because participants in this study were beeped mainly at times that cohabiting partners tend to spend together, there were enough time points available for all but one couple. On average, this selection resulted in 39 reports per couple (SD = 13).[13] We compare the results of analyses including only the moments in which partners were together versus not together in the supplementary materials S6.

Laboratory

Because of technical problems, we ended up not having continuous emotion ratings for 3 of the 101 couples, so we present the results for 98 couples or 196 participants.

Concurrent linkages between partners.—In daily life, Pearson and distance correlations were calculated between each partner's NE over time and the same was done for PE, and EE, resulting in six emotional concurrent linear and non-linear covariation measures for couples. In the lab, Pearson and distance correlations between the partners' emotional experiences throughout the course of both the discussion of the negative and positive topic were calculated. Similarly, Pearson and distance correlations between each partner's emotional extremity during both topics were calculated.

Temporal linkages between partners.—In daily life, we again calculated partial cross-lagged correlations for each individual's NE, PE, and EE separately, representing the correlation between this person's emotion at a certain report and the partner's emotion at a previous report, controlled for own previous emotion. In this way, we obtained measures for each individual's susceptibility for their partner's PE, NE, and EE.

[13]In Study 1, we conducted the analyses for the moments in which partners were together or had been in contact since the previous report. The contact assessment there did not allow for a distinction between the different kinds of contact partners could have had since the previous report, and including only the moments in which partners were together resulted in a low number of time points and seemed too restrictive. In Study 3, we tried to account for these limitations by sampling participants mainly when they were expected to be together, and by using a contact assessment that distinguished between the different kinds of contact partners could have had. Because this procedure optimized the chance of observing emotional interdependence, we decided to report the analyses for these moments. To compare the results with Study 1, we also ran all analyses for those moments in which partners were together or had been in contact since the previous report (thus also including the moments in which they had texted, chatted, or called). These analyses showed very similar results.

In the lab, we did the same for each person's emotional experience and their partner's previous emotional experience, and for each partner's emotional extremity. To decide what lag we would use to capture the previous emotion, we again examined at what lag on average cross-partner correlations were largest (controlling for own emotion at the same lag), with lags ranging from 1 to 100. For the negative topic, this resulted in the selection of lag 16 as the previous emotion, or the emotion that occurred 16 seconds before the current emotion. Interestingly, this is the same lag as the best performing lag in Study 1. For the positive topic, this resulted in the selection of lag 13.

Coupling.—As in Study 2, we used the lab interactions to calculate the improvement in fit when using coupled oscillator models for emotional experience and emotional extremity for each couple by calculating the difference in coefficients of determination (R^2) between the coupled and uncoupled oscillator models. In this way, we obtained two measures that indicated how much evidence there is in the data for coupling of partners' emotions: one for their emotional experience and one for their emotional extremity.

Results

Are emotions between partners interconnected over time? Emotional interdependence in daily life

Concurrent linkages between partners.—On average, partners' emotions tended to fluctuate together more than the emotions of pseudo-couples (Table 6). But, as in our other studies, individual differences were large. Per couple permutation tests revealed that at least two-thirds of the couples did not show more emotional linear covariation than what was likely in pseudo-couples. A few couples demonstrated substantial negative covariation (for NE and EE), meaning that an increase in one partner's emotions went together with a decrease in the other partner's emotion. In terms of distance correlations, somewhat more couples demonstrated evidence for dependence, ranging from 37 to 46 percent.

Temporal linkages between partners.—The effect sizes for participants' susceptibility to their partners' emotions were smaller than what was observed for concurrent covariation, but on average, a change in one's partner's prior emotion tended to predict a similar change in one's own emotion (with the exception of women's emotional susceptibility for their partner's emotional extremity, Table 6). Per individual permutation tests showed that 9 to 16% of the individuals showed more susceptibility to their partners' emotion than was likely in pseudo-couples. Of these persons, 1 in 3 demonstrated a negative pattern, in which an increase in their partners' prior emotion predicted a decrease in their own emotion (and vice versa).

Are emotions between partners interconnected over time: emotional interdependence during a lab interaction

Concurrent linkages between partners.—The average degree of emotional interdependence in couples during an interaction was very similar to the degree of emotional interdependence that had been observed in couples' daily life (see Table 7 for exact

statistics). On average, couples showed more positive linear and non-linear concurrent linkages than pseudo-couples during both the positive and negative topic.

At the individual level, less than one fifth of the couples showed considerably more linear and non-linear covariation than pseudo-couples. The topic of discussion did not seem to matter much. With regards to linear covariation, all but two couples showed positive emotional covariation, meaning that improvements (deteriorations) in their feelings occurred together with improvements (deteriorations) in their partners' feelings.

Temporal linkages between partners.—Again, temporal linkages between partners' emotions were substantially lower than concurrent linkages (Table 7). On average, susceptibility to partners' emotion was not significantly different to that of individuals paired with pseudo-partners. Only for the positive conversation topic did men show significantly stronger susceptibility to their partners' emotional experience in comparison to men in random couples, but this was not the case for women, or in the negative topic. There was no evidence for emotional susceptibility for emotional extremity, regardless of the topic.

Per couple permutation tests disclosed that only 3 to 5% of participants demonstrated substantial susceptibility to their partners' emotion during the negative-topic conversation. For the positive topic, a maximum of 3% showed substantial susceptibility to their partners' emotion. One in 3 of these participants showed negative susceptibility, with their emotion changing in the opposite direction of their partners' previous emotion.

Coupling.—On average, there was no significant evidence for stronger coupling in partners' emotions than in pseudo-couples, except for emotional extremity during the positive topic. Per couple permutation tests showed that 6 to 8 % of the couples demonstrated more coupling than pseudo-couples during the interactions. No large differences were observed depending on the topic of discussion.

Moderating factors of emotional interdependence

Type of emotion.—We focused on daily life measurements to assess the emotion-specificity of emotional interdependence, because it was only there that positive and negative emotions were separately assessed. Detailed analyses and results are reported in the supplementary materials S6, showing that the degree of emotional interdependence observed in one type of emotion, sometimes, but also often not, generalized to other types of emotion.

Type of context.—To examine if the degree of observed emotional interdependence in couples generalized across contexts, we focused on emotional interdependence during the lab interaction because different contexts were explicitly induced there (see Table 8). Nonparametric correlation tests showed that, although other emotional interdependence measures sometimes showed a similar tendency, only the degree of emotional interdependence in terms of distance correlations was positively correlated across topics. Partners who showed more general dependence in their emotional experience during the positive topic also showed more dependence during the negative topic.

Relationship characteristics.—To investigate the potential moderating influence of relationship characteristics, we conducted nonparametric correlation-tests, taking into account gender when individual variables were involved and correcting for multiple testing ($\alpha = .0125$). Amount of time spent together, relationship longevity, and commitment to the relationship were not associated with the degree of observed emotional interdependence (see Table 9 for associations with emotional interdependence in daily life, and Table 10 for associations with emotional interdependence in the lab).

Timescale.—To investigate if couples who showed more emotional interdependence on a second-to-second basis during an interaction also showed more emotional interdependence in daily life, we conducted nonparametric paired correlation tests. None of the emotional interdependence measures in the lab were significantly related to the corresponding emotional interdependence measure in daily life (see Table 11).

Discussion

With Study 3, we replicated and extended the findings of Studies 1 and 2. This study showed that, in general, partners demonstrated more emotional interdependence in the form of concurrent linear and non-linear linkages than randomly composed couples at the mean level, both in daily life and during an interaction in the lab. With regards to temporal linkages, participants on average demonstrated more emotional interdependence than pseudo-couples for some forms of emotions, but not for others, and especially in the lab interaction temporal linkages were not always observed. There was also no strong evidence for coupling of partners' emotions during these interactions.

As in Studies 1 and 2, per couple permutation tests showed that a minority of the couples or the partners demonstrated substantial emotional interdependence for any of the emotional interdependence measures (although the amounts were clearly bigger for some measures than for others). Figure 1 shows some examples. In the lab, the percentage of couples that demonstrated more emotional susceptibility than what fell within the boundaries of pseudo-couples did not exceed the percentage of what could be expected to be Type 1-errors; and there were not many couples whose emotions became coupled during a conversation in the lab.

Results with regard to the consistency of emotional interdependence was mixed. First, the degree to which partners showed concurrent or temporal linkages in daily life was consistent across most, but not all, emotions. Second, the degree to which partners showed concurrent linkages, temporal linkages, and coupling did not clearly generalize across situational contexts in lab interactions. Again, no clear associations were observed between any of the emotional interdependence measures, in the lab and in daily life, and relationship characteristics. Finally, the combination of experience sampling and lab methodology enabled us to examine whether emotional interdependence was consistent across timescale, from daily life to second-to-second measurements, but we found no evidence for this.

General Discussion

We had two aims for this research: 1) to investigate whether and to what extent emotions between partners are interconnected over time, and 2) to examine the consistency and correlates of interconnectedness in relationships. With regard to the first aim, for concurrent linkages, we found that, on average, couples demonstrated stronger covariation in their emotions than randomly composed couples, and effect sizes were small to moderate. Evidence for general interdependence, in which nonlinear concurrent linkages were also taken into account, was somewhat stronger. Temporal linkages were less consistently observed, with averages that were sometimes significantly different than that of pseudo-couples, although with very small effect sizes, but sometimes also not. Further, there was no strong evidence that partners' emotions became more coupled during interactions than the emotions of pseudo-couples. Per couple permutation tests showed that for all linkages, the majority of the couples did not demonstrate any more emotional interdependence than what was found for pseudo-couples.

Again, the specific dynamic characteristic under investigation mattered: only a few couples demonstrated temporal linkages or coupled emotions, while more couples demonstrated general dependence in the form of distance correlations. Whereas the results on more general interdependence support calls to allow for non-linear linkages between partners' emotions (Butner et al., 2017; Butler, 2017; Hollenstein, 2015; Lewis, 2000), the results on coupling do not convincingly support research that stresses its occurrence and importance (e.g., Butner et al., 2005; Sbarra & Hazan, 2009). One possibility is that the interactions between the couples were not salient enough to both partners for coupling to occur (see also Butler & Randall, 2013).

The amount of time that partners spent together did not seem to matter much, and as shown by analyses in the supplementary materials S5, partner presence did neither. This was surprising given the large literature on mechanisms underlying emotional interdependence that require interaction between partners (e.g. Zaki & Williams, 2013). This indicates that apparent linkages between romantic partners can also result from intrapersonal factors that are not caused by actual interpersonal influencing. Of course, it is also possible that in established couples, once they move beyond a minimum level of interaction, additional levels of interaction may not matter.

On top of this, the timescale on which emotional interdependence was assessed, or the context it was assessed in, did not seem to matter greatly for the couples or partners who were considered to be interdependent. Overall, these results line up with existing research that has not only provided evidence for the existence of emotional interdependence, but more recently has suggested that many couples may actually be emotionally independent (e.g., Madhyastha et al. 2011; Steele & Nesselroade, 2014). This study was the first to explicitly perform an exhaustive examination of emotional interdependence in close relationships, allowing us to address issues of generalization across different contexts, making explicit comparisons possible. Unfortunately, the findings do not identify precisely which contexts make emotional linkages clearly appear.

Some people demonstrated negative patterns, or emotions that changed in opposite directions to their partners, which is something that has been observed in other recent studies as well (Randall et al., 2013; Reed et al., 2013). These negative patterns have been suggested to contribute to the couple's emotional homeostasis and may represent coregulation. Also, we observed as much linkage in positive emotions as in negative emotions. In prior research, negative emotions have primarily been found to crossover (Larson & Almeida, 1999) and to covary within couples (Saxbe & Repetti, 2010), and partly because of this, most research has focused on negative emotions. However, there is limited research that has observed covariation between partners' positive emotions in daily life (Butner et al., 2007; Song et al., 2008). Our findings add to this literature, and suggest that emotional interdependence in positive emotions merits more attention, especially because in daily life positive emotions are more frequent than negative emotions and may contribute importantly to couple well-being (Gable et al., 2004). Additionally, positive and negative emotions might be driven by different processes (Watson, Wiese, Vaidya, & Tellegen, 1999), and the same might be the case for linkages between positive versus negative emotions. Indeed, in our studies, cross-partner linkages in negative emotions were related to cross-partner linkages in positive emotions, but not consistently, which supports this reasoning.

Our second aim was to investigate the consistency and correlates of emotional interdependence. The degree of observed emotional interdependence in couples turned out to be surprisingly inconsistent, suggesting that different processes and mechanisms underlie emotional linkages for specific types of emotions, contexts, and timescales. On top of this finding, the degree of emotional interdependence evident in couples was not clearly related to variables that represent the opportunity or the motivation to be emotionally interdependent -- specifically, being together with your partner, amount of time partners spent together, relationship longevity, commitment, and closeness.

We want to note that the power of our studies might have not been sufficient to detect moderators of emotional interdependence below a certain magnitude of effect size. A larger sample would have allowed us to explain more variation. Research on interpersonal emotion dynamics in general requires a trade-off between the amount of observation points within couples (with a bigger number increasing the difficulty of data collection and participant load) and the total sample size (see Butler, in press). Our results clearly suggest that a more fine-grained approach that can investigate both event- and couple level moderators will be necessary to move the field forward.

Emotional interdependence vs interpersonal emotion dynamics

One of the most influential definitions of a close relationship is its characterization in terms of causal interconnections: strong, frequent, and diverse connections between partners' actions, thoughts, and emotions should arise and last over considerable periods of time (Kelley et al., 1983). A logical extension of this definition is that people's emotions are not only influenced to a great extent by their partner in general, but also that their emotions would often be influenced by their partners' emotions; which would result in interconnections between the partners' emotional changes, and increases with closeness of the relationship (see also Randall & Schoebi, 2015; Randall & Schoebi, in press).

From a theoretical point of view, we would thus have expected to observe more convincing evidence for emotional interdependence. One might argue that interdependence theories, and most theories in general, hypothesize emotional interdependence to occur only in certain circumstances, and therefore linkages might exist, but remain hidden and consequently appear invisible (they thus only have “the potential for high affective involvement”, Kelley, 1979; Kelley et al, 1983). For instance, according to the emotion-in-relationships-model, emotional linkages become visible mainly when regular interaction sequences between partners are disrupted (Berscheid, 1983). Additionally, coregulation would only arise when a stressor pulls the couple away from homeostasis (Butler & Randall, 2013); and contagion would primarily happen when there is an element of insecurity and the source of emotion is unclear (Hatfield et al., 1994). Nevertheless, even if such emotional influence only occurs sometimes, this still would have to result in higher emotional linkages than the linkages that appear between people who have never interacted with each other (i.e., pseudo-couples). Further, in Study 3, emotional interdependence was explicitly assessed during an interaction about a negative topic (“what annoys you most about each other”) that would normally disrupt the couple and act as a stressor. Still, the observed degree of emotional interdependence in this context did not differ from the degree of emotional interdependence that was observed during a positive interaction or during daily life. In fact, the observed degree of emotional interdependence was higher during the positive interaction than during the negative interaction.

At least three different possible implications can be derived from these findings: (1) emotional interdependence might not be so important in romantic relationships nor say much about closeness after all, (2) the measures that are currently used or suggested to capture such emotional connections fail to actually do so, or (3) there is a need to better define emotional interdependence.

The first possibility seems unlikely as abundant research has shown that partners indeed become interdependent on each other, and are impacted by each other in numerous ways (for overviews, see e.g., Clark & Reis, 1988; Reis et al., 2000). However, because the original interdependence theories are complex and contain many nuances, it seems plausible that emotion dynamics in close relationships cannot be approached as a simple function of the degree of interdependence between the two partners. Instead, more complex theoretical patterns might be necessary (Kelley et al., 2003). Research on interpersonal emotion dynamics has been on the rise, and although many potentially fruitful alternative models have been suggested, an accurate understanding of these dynamics and an encompassing theoretical framework is still lacking (Butler, in press; Randall & Schoebi, in press). Our findings thus point to an important task for the field: to develop an accurate, explanatory understanding of interpersonal emotion dynamics.

The finding that the degree of emotional interdependence displayed by each couple was context-dependent strongly indicates that the context of the interpersonal emotions under investigation cannot be disregarded (see also Butler, 2011; 2015). One difficulty with interpersonal emotion linkages is the principle of equifinality: different processes and contexts can give rise to the same statistical pattern. For instance, especially during daily life, partners’ negative emotions can covary due to partners responding with negative affect

towards each other during a conflict (negative affect reciprocity), but also due to partners responding with equally intense negative affect when a shared goal is obstructed (Butler, in press; Randall & Schoebi, in press). This also implies that existing findings on individual differences that moderate emotional interdependence in couples should be interpreted in a context-dependent manner.

The second possibility, which is that the measures that are currently used to capture emotional connections do not succeed in this goal, seems intuitively reasonable. However, these studies exhaustively examined two of the most common ways that researchers study couples' emotion -- in-lab conversations and experience sampling -- with a diverse set of rigorous analyses -- linear and nonlinear linkages between, partners' emotions, and influences on partners' emotional cycles. Moreover, emotional extremity represented every occurrence of any emotional experience in one partner coinciding with or predicting any emotional experience in the other partner, thus allowing for very different kinds of linkages that might arise between partners. If these measures are not capturing emotional interdependence between partners, an important question is what sorts of measures would do so.

To be sure, some of our results point to the possibility that some sort of similarity between partners is captured by interpersonal linkages, as opposed to actual interpersonal influence processes. First, concurrent linkages were greater than temporal linkages. Second, pseudo-couples or people who have never interacted also sometimes showed a high degree of linkage. Finally, follow-up analyses (that can be found in supplementary materials S5) revealed that even when partners were not together, the degree of interconnection observed was greater than zero, and often not different from the degree of interconnection observed when partners were together. People in close relationships have indeed been shown to resemble each other in several domains, including emotions, and recent findings suggest that this might be due primarily to selection processes rather than to social influence (Bahns et al, 2016; Gonzaga et al, 2010; Segrin, 2004). An important goal for future research is to distinguish between similarity that is due to selection or actual influence processes. Further, an explicit comparison in the degree of emotional linkages that can be observed between people in different sorts of close and less close relationships would provide further insight by showing to what extent our findings are specific to romantic relationships.

Another potential reason why our studies did not capture higher levels of emotional interdependence is that partners are often ignorant of what their partner is feeling. Partners must first be aware of each other's emotions before these emotions can influence how they feel themselves (e.g., Levenson & Ruef, 1997). To this end, partners have to be motivated to notice their partners' emotions, which is likely to vary with the specific situation and stable traits of the self and partner (Ickes & Simpson, 2001). How empathic accuracy, emotional interdependence, and situational and trait motivation interact to potentially produce emotional influence is a topic that deserves more attention (Zaki, 2014).

We think that the third possibility, that there is a need to better define emotional interdependence, might be important. Instead of focusing on emotional interdependence as direct emotion-emotion connections, every partner influence on one's emotion could be

considered emotional interdependence (see also Reis, 2014). That is, and as follows from the Kelley et al. (1983) definition, partners can influence each other's emotions in ways other than by their emotions, notably involving perceptions or behavior. For instance, Sels, Ceulemans, and Kuppens (2017) recently found first evidence that people's perceptions of their partners' feelings positively predicted how their partner actually felt at a later moment in time throughout daily life. Also, people's actions -- for example, a compliment or an insult -- may influence their partners' emotions even if the original act had no emotional basis. A further complexity is added by the possibility that whereas actual emotional interdependence may only characterize close relationships in specific contexts, perceived emotional interdependence - thinking that one is emotionally in tune with a partner - may be more prevalent and possibly more relevant for couple well-being (see also Sels et al, 2019). In short, our research suggests that an explicit focus on other dynamic patterns involving people's emotions besides direct emotion-emotion connections might be an avenue worth exploring.

Conclusion

The current study extended existing research on interpersonal emotion dynamics in several ways. First, this research is the first to explicitly, systematically, and comprehensively investigate emotional interdependence across different interpersonal linkages, types of emotions, contexts, and situations. Second, these are the only studies of which we are aware that examine consistency in the relative degree of emotional interdependence within couples. Finally, we proposed and tested aspects of one of the most impactful and abstract relationship theories (interdependence theories), trying to integrate a more relationship-theoretical perspective into interpersonal emotion dynamic research. We found that direct emotional connections between partners have small to moderate effects, are difficult to observe with the existing methods in most couples, may not generalize across studies, and do not seem to be an indicator of closeness of a relationship. Together, we hope that these findings contribute to a better understanding of both interpersonal emotion dynamics and romantic relationships.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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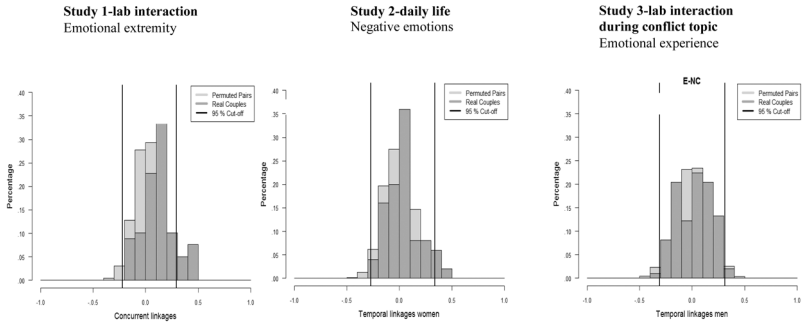

Figure 1.

Examples from the three studies, showing the percentages of emotional interdependence observed in original and pseudo-couples for certain types of linkages (temporal and concurrent), emotions (negative emotions, emotional extremity, and emotional experience in terms of valence), samples and timescales (hourly in daily life and second-to-second in a lab interaction). Light grey indicates the percentages for the permuted pairs, dark grey indicates the percentages for the real couples, and the vertical lines mark the boundaries for the 95 % confidence interval of what can be expected to be found in pseudo-couples.

Table 1

Investigated emotion dynamic characteristics per study.

	Study 1 (lab)	Study 2 (ESM)	Study 3 (lab part)	Study 3 (ESM-part)
Concurrent linkages				
Linear (Pearson correlation)	E	NE	E	NE
	EE	PE	EE	PE
		EE		EE
Linear and non-linear or general interdependence	E	NE	E	NE
(distance correlation)	EE	PE	EE	PE
		EE		EE
Temporal linkages	E	NE	E	NE
(partial Pearson cross-lagged correlations)	EE	PE	EE	PE
		EE		EE
Coupling	E	NE	E	NE
(R2 difference for coupled and uncoupled linear oscillator models)	EE	PE	EE	PE
		EE		EE

Note. E= emotional experience, EE = emotional extremity, NE = negative emotion, PE = positive emotion

Table 2

Study 1: Emotional Interdependence During a Lab Interaction: Descriptive Statistics and Comparison with Permuted Couples

	Real couples						Permuted couples					
	M	***Mdn***	***SD***	***Min***	***Max***	***p-value***	***M***	***Mdn***	**Critical value lowest %**	**Critical value highest %**	**#pos**	**#neg**
Concurrent linkages												
r												
E	.30	.31	.22	−.53	.69	<.01	.01	.01	−.37	.40	27	1
EE	.12	.13	.15	−.20	.46	<.01	.02	.02	−.22	.29	11	0
d*r*												
E	.36	.34	.14	.11	.66	<.01	.22	.20	/	.41	30	/
EE	.20	.19	.10	.06	.48	<.01	.16	.15	/	.29	14	/
Temporal linkages (*r*)												
Women												
E	.07	.08	.13	−.38	.38	<.01	.00	.00	−.26	.26	4	2
EE	.04	.03	.10	−.14	.28	.18	.01	.01	−.19	.23	2	0
Men												
E	.11	.12	.12	−.38	.32	<.01	.00	.00	−.26	.27	6	1
EE	.03	.02	.11	−.21	.35	.54	.02	.02	−.19	.23	2	2
Coupling												
E	.05	.03	.04	−.00	.19	.92	.05	.04	/	.13	5	/
EE	.02	.01	.03	−.00	.17	.61	.02	.02	/	.08	5	/

Note: E = emotion, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation, *p-value* = *p-value* for the permutation test at the mean level, #pos = number of couples/individuals that exceeds the highest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages) or the highest 5 % for distance correlations (d*r*) and coupling indicators, #neg = number of couples/individuals that exceeds the lowest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages).

Table 3

Study 1: Emotional Interdependence in a Lab Interaction: Associations with Variables that Might Moderate Opportunity and Motivation

	Relationship longevity		Commitment	
	r_s	*p*	r_s	*p*
Concurrent linkages				
r				
E	.08	.47	−.03	.73
EE	−.03	.82	−.04	.63
d*r*				
E	.09	.41	−.03	.75
EE	.01	.96	.03	.73
Temporal linkages (r)				
E	.04	.58	−.05	.56
EE	−.03	.70	−.12	.15
Coupling				
E	.12	.31	−.08	.35
EE	.02	.89	−.08	.37

Note: E = emotion, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation.

* = significant at .025 level.

Table 4

Study 2: Emotional Interdependence: Descriptive Statistics and Comparison with Permuted Couples

	Real couples						Permuted couples				#pos	#neg
	M	***Mdn***	***SD***	***Min***	***Max***	***p-value***	***M***	***Mdn***	**Critical value lowest %**	**Critical value highest %**		
Concurrent linkages												
r												
NE	.25	.25	.24	−.28	.73	<.01	−.00	−.02	−.29	.37	18	0
PE	.24	.28	.24	−.24	.71	<.01	.02	.02	−.33	.41	13	0
EE	.16	.15	.19	−.17	.54	<.01	.01	−.00	−.23	.31	13	0
d*r*												
NE	.35	.32	.14	.07	.68	<.01	.23	.21	/	.39	17	/
PE	.36	.34	.13	.16	.68	<.01	.27	.25	/	.43	14	/
EE	.29	.27	.09	.16	.55	<.01	.23	.21	/	.33	14	/
Temporal linkages (*r*)												
Women												
NE	.04	.04	.16	−.25	.42	10	.00	−.02	−.26	.34	3	0
PE	.06	.07	.15	−.25	.33	.19	.01	.02	−.28	.27	3	0
EE	.01	.02	.20	−.35	.55	.57	.01	−.00	−.28	.32	3	3
Men												
NE	−.00	−.01	.16	−.42	.38	.65	.02	−.00	−.28	.43	0	2
PE	.03	.04	.17	−.50	.31	.62	.01	−.00	−.29	.32	0	1
EE	.04	.01	.18	−.28	.44	.32	.01	−.00	−.27	.39	1	1

Note: NE = negative emotions, PE = positive emotions, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation, *p-value* = *p-value* for the permutation test at the mean level, #pos = number of couples/individuals that exceeds the highest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages) or the highest 5 % for distance correlations (d*r*) and coupling indicators, #neg = number of couples/individuals that exceeds the lowest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages).

Table 5

Study 2: Emotional Interdependence: Associations with Variables that Might Moderate Opportunity and Motivation

	Amount of time spent together		Relationship Longevity		Cohabitation Status			
	r_s	*p*	r_s	*p*	$M_{cohabiting}$	$M_{non\text{-}cohabiting}$	*t*	*p*
Concurrent linkages								
r								
NE	.09	.54	−.02	.88	.29	.21	1.61	.25
PE	.30	.03	.22	.13	.29	.17	1.82	.07
EE	.17	.23	.08	.57	.21	.10	2.21	.03
d*r*								
NE	.07	.64	−.06	.69	.36	.33	0.86	.39
PE	.37	<.01*	.22	.12	.39	.33	1.90	.06
EE	.24	.09	.11	.44	.32	.25	2.78	.01*
Temporal linkages (*r*)								
NE	.12	.22	.07	.50	.03	−.04	1.58	.12
PE	.00	.97	−.03	.80	.04	.03	0.23	.82
EE	.05	.60	−.02	.87	.06	.01	0.99	.33

Note: NE = negative emotions, PE = positive emotions, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation,

*Significant at .017 significance level.

Table 6

Study 3: Emotional Interdependence in Daily Life: Descriptive Statistics and Comparison with Permuted Couples

		Real couples						Permuted couples					
		M	***Mdn***	***SD***	***Min***	***Max***	***p-value***	***M***	***Mdn***	**Critical value lowest %**	**Critical value highest %**	**#pos**	**#neg**
Concurrent linkages													
r													
	NE	.23	.22	.32	−.64	.90	<.01	.01	−.02	−.30	.41	29	3
	PE	.31	.31	.22	−.33	.77	<.01	.03	.02	−.37	.41	32	0
	EE	.17	.15	.25	−.50	.77	<.01	.00	−.02	−.25	.34	24	3
d*r*													
	NE	.39	.33	.20	.09	.92	<.01	.24	.23	/	.41	36	/
	PE	.41	.37	.14	.15	.76	<.01	.27	.26	/	.44	35	/
	EE	.35	.35	.12	.18	.72	<.01	.25	.23	/	.36	43	/
Temporal linkages (*r*)													
Women													
	NE	.05	.05	.21	−.56	.70	<.01	−.00	−.02	−.30	.36	7	4
	PE	.06	.06	.22	−.75	.88	<.01	.01	.01	−.32	.34	7	2
	EE	.03	.02	.21	−.57	.59	.10	.00	−.02	−.26	.37	6	6
Men													
	NE	.08	.06	.23	−.50	.81	<.01	.00	−.01	−.29	.37	9	3
	PE	.09	.13	.19	−.49	.50	<.01	.01	.02	−.30	.34	6	2
	EE	.07	.06	.25	−.67	.74	<.01	.00	−.01	−.26	.35	12	6

Note: NE = negative emotions, PE = positive emotions, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation, *p-value* = *p-value* for the permutation test at the mean level, #pos = number of couples/individuals that exceeds the highest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages) or the highest 5 % for distance correlations (d*r*) and coupling indicators, #neg = number of couples/individuals that exceeds the lowest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages).

Table 7

Study 3: Emotional Interdependence During a Lab Interaction: Descriptive Statistics and Comparison with Permuted Couples

	Real couples						Permuted couples					
	M	***Mdn***	***SD***	***Min***	***Max***	***p-value***	***M***	***Mdn***	**Critical value lowest %**	**Critical value highest %**	**#pos**	**#neg**
Concurrent linkages												
r												
E during NT	.20	.21	.27	−.51	.76	<.01	.00	.00	−.44	.45	18	1
E during PT	.29	.29	.27	−.34	.90	<.01	.12	.12	−.34	.59	13	0
EE during NT	.08	.07	.17	−.30	.52	<.01	.01	.01	−.28	.35	6	1
EE during PT	.10	.07	.19	−.28	.72	<.01	.03	.02	−.29	.39	8	0
d*r*												
E during NT	.33	.30	.16	.09	.77	<.01	.27	.25	/	.48	21	/
E during PT	.39	.36	.18	.06	.94	<.01	.30	.27	/	.57	16	/
EE during NT	.22	.19	.10	.09	.62	<.01	.20	.19	/	.36	8	/
EE during PT	.24	.21	.12	.06	.76	<.01	.22	.20	/	.39	10	/
Temporal linkages (*r*) Women												
E during NT	.03	.02	.14	−.28	.40	.06	−.00	.00	−.31	.30	3	0
E during PT	.04	.07	.15	−.35	.32	.05	.02	.03	−.32	.30	1	2
EE during NT	.02	.02	.15	−.28	.46	.15	.00	−.00	−.25	.28	6	2
EE during PT	.00	.01	.14	−.32	.29	.72	.01	.01	−.25	.29	1	3
Men												
E during NT	.02	.03	.16	−.31	.35	.20	.00	.00	−.31	.31	2	1
E during PT	.07	.07	.13	−.25	.34	<.01	.03	.04	−.28	.30	2	0
EE during NT	.02	.02	.12	−.34	.28	.23	.01	.01	−.24	.28	0	1
EE during PT	.01	.00	.13	−.21	.55	.69	.01	.00	−.24	.28	2	0
Coupling												
E during NT	.05	.04	.05	.00	.27	.32	.05	.04	/	.13	8	/
E during PT	.05	.03	.05	.00	.29	.04	.04	.03	/	.12	6	/
EE during NT	.03	.03	.03	.00	.14	.21	.03	.03	/	.08	8	/
EE during PT	.04	.02	.04	−.00	.15	.05	.03	.03	/	.10	8	/

Note: E = emotional experience, EE = emotional extremity, NT = negative topic, PT = positive topic, *r* = Pearson correlation, d*r* = distance correlation, *p-value* = *p-value* for the permutation test at the mean level, #pos = number of couples/individuals that exceeds the highest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages) or the highest 5 % for distance correlations (d*r*) and coupling indicators, #neg = number of couples/individuals that exceeds the lowest 2.5 % of the distribution for the pseudo-couples for Pearson correlations (*r* and temporal linkages).

Table 8

Association Between the Degree of Emotional Interdependence Observed During the Positive Topic and the Degree of Emotional Interdependence Observed During the Negative Topic.

	r_s	*p*
Concurrent linkages		
Concurrent linear covariation (Pearson correlations)		
E	.19	.07
EE	−.04	.72
Concurrent linear and non-linear covariation (distance correlations)		
E	.23	.02*
EE	.18	.08
Temporal linkages		
Emotional susceptibility (partial Pearson cross-lagged correlations)		
Women		
E	.01	.89
EE	−.02	.85
Men		
E	.01	.92
EE	−.10	.35
Coupling (R^2 difference of coupled and uncoupled linear oscillator models)		
E	.04	.68
EE	.18	.08

Note: E = emotional experience, EE = emotional extremity.

* is significant at .05

Table 9

Study 3: Emotional Interdependence in Daily Life: Associations with Variables that Might Moderate Opportunity and Motivation

	Amount of time spent together		Relationship Longevity		Commitment		Closeness	
	r_s	*p*	r_s	*p*	r_s	*p*	r_s	*p*
Concurrent linkages								
r								
NE	.05	.63	−.15	.15	−.07	.38	−.02	.79
PE	−.04	.67	−.13	.21	−.02	.78	−.01	.93
EE	.25	.02	−.12	.25	−.07	.37	.00	.99
d*r*								
NE	−.13	.22	−.09	.39	−.07	.33	−.04	.60
PE	−.12	.24	−.18	.08	−.05	.51	.00	.98
EE	−.16	.14	−.15	.15	−.12	.09	−.08	.31
Temporal linkages (r)								
NE	.13	.08	.03	.65	−.08	.26	−.12	.12
PE	−.02	.80	.00	.97	.03	.68	−.05	.49
EE	.05	.55	.06	.45	−.07	.35	−.15	.04

Note: NE = negative emotions, PE = positive emotions, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation.

* is significant at .0125

Table 10

Study 3: Emotional Interdependence in a Lab Interaction: Associations with Variables that Might Moderate Opportunity and Motivation

	Relationship longevity		Amount of time spent together		Commitment		Closeness	
	r_s	*p*	r_s	*p*	r_s	*p*	r_s	*p*
Concurrent linkages								
r								
E during NT	.01	.94	−.08	.48	−.03	.73	.06	.41
E during PT	.00	.99	−.02	.83	−.07	.35	−.04	.60
EE during NT	−.08	.44	−.06	.58	−.08	.27	.01	.93
EE during PT	.03	.75	−.07	.53	.02	.78	.13	.09
d*r*								
E during NT	.05	.66	−.04	.72	−.05	.51	.07	.37
E during PT	.11	.30	−.05	.67	−.11	.13	−.04	.62
EE during NT	.04	.73	.02	.83	−.01	.92	.04	.56
EE during PT	.02	.84	−.13	.23	−.06	.39	.06	.40
Temporal linkages (*r*)								
E during NT	−.04	.57	−.05	.50	−.02	.80	.03	.67
E during PT	−.09	.25	−.05	.53	−.04	.64	−.08	.30
EE during NT	−.06	.46	.00	.97	.07	.36	.04	.63
EE during PT	.06	.42	−.11	.14	−.05	.53	−.01	.94
Coupling								
E during NT	−.09	.38	.07	.48	.14	.07	.14	.07
E during PT	.03	.80	−.19	.07	−.18	.02	−.09	.21
EE during NT	−.03	.75	.07	.52	.03	.70	−.07	.36
EE during PT	−.09	.40	−.08	.47	.09	.25	.10	.19

Note: E = emotional experience, EE = emotional extremity, NT = negative topic, PT = positive topic, *r* = Pearson correlation, d*r* = distance correlation.

* is significant at .0125

Table 11

Study 3: Emotional Interdependence in Couples: Consistency across Timescale

Lab		Daily life					
		NE		PE		EE	
		r_s	*p*	r_s	*p*	r_s	*p*
Concurrent linkages							
r							
	E during negative topic	.03	.74	.15	.14	−.03	.81
	E during positive topic	.15	.15	.09	.40	.19	.08
	EE during negative topic	.00	1.00	.10	.35	−.05	.61
	EE during positive topic	−.04	.68	−.07	.50	−.11	.32
d*r*							
	E during negative topic	−.02	.84	.05	.62	−.03	.74
	E during positive topic	.13	.23	.05	.62	.02	.86
	EE during negative topic	.08	.43	.08	.45	−.06	.59
	EE during positive topic	.02	.85	−.10	.37	−.02	.82
Temporal linkages (*r)*							
Women							
	E during negative topic	.01	.94	.06	.61	.03	.77
	E during positive topic	−.21	.05	.06	.58	.00	.99
	EE during negative topic	−.02	.84	−.09	.42	.06	.58
	EE during positive topic	−.20	.06	−.10	.33	−.04	.74
Men							
	E during negative topic	−.03	.80	−.04	.71	.09	.38
	E during positive topic	.10	.38	−.01	.92	.02	.86
	EE during negative topic	.06	.60	.10	.36	.07	.54
	EE during positive topic	.01	.93	.08	.47	−.14	.21

Note: E = emotional experience, EE = emotional extremity, *r* = Pearson correlation, d*r* = distance correlation.

*
significant at .. .**$ is sig**