JSPR

Journal of Social and Personal Relationships
2022, Vol. 0(0) 1–10

DOI: 10.1177/02654075221119427
journals.sagepub.com/home/spr
SAGE

Introduction to the special issue: Nonlinear effects and dynamics in close relationships

Yuthika U Girme[1], Nickola C Overall[2] and Jeffry A Simpson[3]

Abstract

Relationship processes often involve fluctuating, variable, or tumultuous dynamics. Yet, close relationship models have traditionally focused on linear processes. The purpose of this *Journal of Social and Personal Relationships* special issue is to provide examples of how modeling nonlinear effects and dynamics can: (I) test nonlinear theoretical assumptions, (II) reconcile inconsistencies and reveal novel effects, (III) detect dynamic shifts in core relationship constructs, and (IV) capture temporal and spatial synchrony between partners within dyads. By showcasing a variety of nonlinear applications, we hope to encourage close relationship scholars to utilize similar nonlinear methods in order to advance relationship science by discovering common and important, but currently under-examined, relationship processes.

Keywords

nonlinear, fluctuations, variation, curvilinear, synchrony, dyadic

A call to action

Close relationships are a central determinant of health and wellbeing (Holt-Lunstad, 2018; Robles et al., 2014), but understanding how they develop and remain secure, satisfying, and stable over time has been challenging. Understanding how and why the desires,

[1]Department of Psychology, Simon Fraser University, Burnaby, Canada
[2]School of Psychology, University of Auckland, Auckland, New Zealand
[3]University of Minnesota, Minneapolis, MI, USA

Corresponding author:
Yuthika U Girme, Department of Psychology, Simon Fraser University, 8888 University Drive, Burnaby V5A 1S6, Canada.
Email: ygirme@sfu.ca

needs, and beliefs of one person are associated with these outcomes is complicated enough. How, then, can relationship scholars comprehend the even more complex, interconnected relationships between two people that change across time, sometimes in tumultuous and unpredictable ways? For example, Marie and Lydia are a committed couple who describe the early stages of their relationship as a "whirlwind romance", but they have noticed that passion in their relationship ebbs and flows now that they have young children (a process involving greater variation or fluctuation). Morgan and Mateo, another committed couple, experience relationship conflicts that tend to escalate unpredictably (a process involving abrupt shifts), making it challenging for each of them to regulate their emotions and become attuned with each other (or find dyadic synchrony). Priya and Jason have just started a relationship. Initially, Priya thought it was sweet when Jason got a little jealous when she spent time with her male friends, but recently Jason has gotten overly jealous, leading Priya to reconsider whether she wants to stay in the relationship (a curvilinear effect of jealousy).

To date, relationship scientists have explored these different types of relationship phenomena by employing statistical techniques that account for the inherent interdependence that exists between relationship partners (Kenny et al., 2006; also see Cook & Kenny, 2005). Scholars also have utilized within-person (as opposed to between-group) analyses to investigate how relationship processes unfold within each individual (partner) or dyad in different social contexts and across time (Bolger & Laurenceau, 2013; Gable & Reis, 1999). These statistical methods have enhanced our understanding of close relationship processes, but they have predominately been used to examine linear effects. Yet, as the three examples above illustrate, many important relationship processes operate in non-linear ways, leading to calls for the application of nonlinear models within relationship science (e.g., Gable & Reis, 1999; Girme, 2020; Gottman, 2002). Though growing, there are relatively few empirical examinations of non-linear effects in the field of close relationships (for exceptions, see Arriaga, 2001; Don et al., 2022; Eller et al., in press; Girme et al., 2015, 2018, 2021a; Gunaydin et al., 2021; Muise et al., 2016; Overall, 2020), and even fewer theoretical models that explicitly incorporate nonlinear dynamics (for exceptions, see Eastwick et al., 2019; Solomon & Knobloch, 2004). The current special issue showcases new tools to assess and model different types of non-linear dynamics in close relationships. While doing so, it highlights the value of adopting nonlinear perspectives, including: (I) testing nonlinear theoretical assumptions, (II) reconciling inconsistencies and revealing novel relationship effects, (III) detecting dynamic shifts in core relationship constructs, and (IV) capturing temporal and spatial synchrony between relationship partners.

Special issue aims and resources

The fundamental aim of this special issue is to illustrate ways in which modeling nonlinear effects and dynamics can facilitate our understanding of common relationship experiences and broaden our understanding of complex relationship processes. We construe "nonlinear" effects and dynamics broadly, and the papers in this special issue demonstrate a range of statistical techniques designed to capture different relationship processes that can change in tumultuous and variable ways across time, situations, and partners. For example, nonlinearity can be defined as a function of patterns between variables (e.g., curvilinear effects, Chopik et al., 2022, Lafit et al., 2022; also see correlated intercepts, slopes or residuals, Dugan et al., 2022), within variables over time (e.g., within-person variation, Eller et al., 2022), and/or within variables between dyads (e.g., time-series analyses, Ogolsky et al., 2021). More complex models can reveal the dynamic ways in which partners' emotions (e.g., change point detection, Sels et al., 2022), behaviors (e.g., sequence analysis, Solomon et al., 2022), or physiological responses (e.g., couple-oscillator model, Kuelz et al., 2022), unfold or shift abruptly across time. We recognize that most of these analyses are inherently linear in that they involve extracting variables that represent nonlinear effects or dynamics to include in linear-based models to predict outcomes. We believe that these applications provide an important first step to encourage wider theoretical and empirical applications examining nonlinear processes in close relationships. The applications that appear in this special issue do not represent an exhaustive list; instead, they serve as examples of how nonlinear methods can be applied to address important questions and processes targeted within the field.

To facilitate the aim of providing scholars with good examples of how nonlinear models can advance close relationships research, we asked the authors invited for this special issue to include the following information in their papers: Identify why nonlinear processes are theoretically important for addressing their research question(s), or what types of research questions can be answered using their proposed methodological or statistical tool. We also encouraged the authors to provide clear and detailed information so scholars interested in replicating their methods/analyses can do so easily by: (1) providing details about how to structure datasets, (2) providing example code and output for analyses, and (3) making publicly available the data and code for the results they presented. This information appears in the papers, but authors also included online supplementary materials (OSM) and/or used the open science framework (OSF) to provide more detailed information.

One resource appearing in this special issue that we hope will be applicable to many scholars is a power analysis app called "PowerLAPIM". Lafit et al., (2022) provide details about the "PowerLAPIM" app, which they have developed for conducting power analyses for linear and quadratic (curvilinear) longitudinal APIM models. Lafit and colleagues outline 24 different possible models, based on whether dyads are distinguishable, whether the models include linear and/or quadratic effects, and the inclusion of various types of moderators. "PowerLAPIM" is a user-friendly web-based tool that provides scholars with information about the number of dyads required to conduct well-powered dyadic longitudinal analyses, and it is especially relevant for scholars interested in estimating statistical power for curvilinear longitudinal effects. In sum, we hope that the variety of nonlinear applications and additional resources provided in this special issue will encourage a growing number of close relationships scholars to adopt nonlinear methods.

Why are nonlinear effects and dynamics important?

There are several advantages of examining nonlinear effects and dynamics in close relationships. We briefly highlight four key reasons why modelling nonlinear effects and dynamics are important for advancing close relationships theory and research, each of which dovetail with salient themes that emerged across the papers in this special issue.

Theme I: Central relationship theories imply nonlinear effects and dynamics

Several theories involving close relationships allude to underlying processes that are nonlinear by nature, yet have only been tested using linear modelling. Properly modelling nonlinear effects and dynamics, however, can directly test these pivotal processes. Two papers in this special issue utilize nonlinear models to test central tenets of one of the most influential theories in close relationships – attachment theory. According to attachment theory, both high quality and *consistent* caregiving is required to foster greater attachment security. Although quality caregiving has been studied extensively, most work on attachment has not paid much attention to consistency versus fluctuations in caregivers' responsiveness (see Girme et al., 2021b; Gunaydin et al., 2021; Eller et al, in press, for exceptions). Eller et al., (2022) show that, beyond mean levels in the quality of maternal sensitivity received across early-to-middle childhood, inconsistent caregiving (i.e., greater within-person standard deviation in maternal sensitivity) has unique, deleterious consequences for the development of attachment security and relationship effectiveness years later in adulthood.

Another core tenet of attachment theory is that attachment working models are hierarchically structured (Overall et al., 2003), with people having both relationship-specific and global working models. Prior research has documented ways in which attachment representations can and do change over time (e.g., Simpson et al., 2003), but it remains unclear exactly *how* these changes occur. Dugan et al. (2022) employ bivariate growth curve models to examine associations among long-term changes (slope-slope correlations) and short-term fluctuations (correlations among residuals) in different working models or attachment representations. Their results provide important theoretical insights into the dynamic ways in which attachment representations change and how short-term fluctuations in working models can "reverberate through [people's] network of attachment representations" (pg. 23).

Theme II: Nonlinear applications can reconcile inconsistencies and reveal novel effects

As is true of many fields, relationship science is fraught with inconsistent findings: social support is beneficial, but can also backfire (Girme et al., 2015); conflict is destructive, but it can also be diagnostic and helpful (Overall, 2020); sexual frequency is important for relationship functioning, but life often gets in the way (Muise et al., 2016). Linear models may reveal inconsistent effects because they do not model the association between variables along the full range of values (e.g., curvilinear effects) or because they mask important sources of variation in the data (e.g., fluctuation effects; see Girme, 2020). Nonlinear applications can reconcile inconsistencies in associations that occur at different levels and can sometimes reveal novel effects that may be missed when simply modelling linear effects. In this special issue, Chopik et al. (2022) provide one such example. The literature on the association between age and gratitude is mixed: Different studies have produced contrary evidence that gratitude peaks either in younger age, middle age, or older age, with some studies revealing null associations (see Chopik et al., 2019). Chopik et al. (2022) report a cubic effect of age (age^3) that is consistent across cultures, with gratitude levels being low and stable among adolescence, then gradually increasing across middle age, and finally stabilizing in older age. This pattern reflects nonlinear changes in gratitude across the lifespan that has never been captured by previous studies examining linear associations.

Theme III: Relationship interactions involve nonlinear dynamic shifts

Behavioral observation, such as video-recording dyads engaged in discussions, is one of the strongest methods used to measure and witness interpersonal processes that forecast long-term relationship outcomes (Baumeister et al., 2007; Gottman & Notarius, 2000). Observation methods often involve independent coders who rate each partner's emotions and behaviors across the discussion, which provides very rich data to examine key dyadic processes in diagnostic social interactions (Overall et al., 2016). The resulting quantitative measures and data analytic techniques, however, typically fail to consider the multitude of ways in which conversations unfold. One paper in the special issue introduces a useful tool to examine how dyadic conversations progress. Solomon et al. (2022) use sequence analysis to identify different patterns of sequential behavior based on categorical shifts during couples' discussions, such as Morgan disclosing a problem, Mateo clarifying it with a question, Morgan elaborating more, Mateo reflecting on what is said, and then ending with Mateo providing advice. Different sequential patterns, or "conversational motifs", can then be used to predict key outcomes, such as which conversational motifs are associated with discussion success, or whether individual or dyadic characteristics predict certain conversational motifs, such as what types of couples tend to engage in optimal conversational motifs.

Considering nonlinear dynamics also enhances our understanding of processes within dyadic interactions by highlighting that important and consequential changes in emotion, behavior, or communication may not reflect incremental, linear effects across interactions. Indeed, another paper in this special issue shows how nonlinear models can identify abrupt shifts during conversations. Sels et al. (2022) introduce change point detection analysis, which allows researchers to detect sudden shifts in emotions during dyadic discussions. The method Sels et al. illustrate identifies whether abrupt changes are experienced by both dyad members simultaneously, such as Morgan and Mateo both suddenly getting angry, or whether abrupt changes are isolated to one member of the dyad, such as Morgan suddenly gets angry, but Mateo does not. These critical moments may have important implications for the trajectory of dyadic discussions, such as serving as catalysts for couples to become more versus less attuned or synchronized ("on the same page") following critical change points. These types of abrupt changes may be a critical element of couples' discussions that remain undetected when researchers rely on global assessments or linear modeling.

Theme IV: Nonlinear dynamics involve temporal and spatial synchrony between partners

One defining feature of close relationships is that dyad members (partners) are highly interdependent—each person's experiences and outcomes are inherently linked by mutual dependence and influence (Kelley et al., 2003; Kelley & Thibaut, 1978). Relationship science typically accounts for this interdependence by examining contemporaneous and longitudinal partner effects (i.e., how Morgan's behavior impacts Mateo's outcomes; Cook & Kenny, 2005). Two papers in this special issue, however, illustrate how nonlinear modelling can identify additional dyadic processes involving patterns of synchrony between relationship partners. Kuelz et al., (2022), for example, use the R statistical package *rties* (Butler & Barnard, 2019) to model different patterns of physiological synchrony between dyad members using a coupled oscillator model. Using this method, they: (a) identify distinct patterns of physiological synchrony (such as when partners' physiologies counterbalance, but never achieve homeostasis or stability), and (b) illustrate what partner and couple characteristics might predict distinct patterns of physiological synchrony (such as whether dissatisfied couples have more maladaptive patterns of physiological synchrony).

Although typically conceived as unfolding across time during specific interactions, dyadic interactions also occur at varying levels of proximity. Ogolsky et al., (2021) link continuous measures of individuals' spatial proximity in their homes with their partner's heart rates during daily life to determine whether and how proximity is associated with both partner's physiological responses. Data across three time-series profiles illustrate that not only does lagged-feedback (i.e., cross-correlations across time) emerge between husbands' heart rate, wives' heart rate, and each couple's proximity, but that predicting any of these variables requires critical information about the other two variables. For example, Morgan's heart rate might increase 3 minutes after Mateo's heart rate increases *and* as the proximity between Morgan and Mateo decreases. In sum, nonlinear models not only confirm that close relationships are highly interdependent; they also provide nuanced information about distinct patterns of synchrony in dyads and the novel consequences of these interaction dynamics.

Concluding remarks

Nonlinear techniques and methods offer scholars a powerful tool to better understand and reveal unknown or under-explored dynamic processes that both define and affect close relationships. We thank the scholars who contributed to this special issue for offering such good, novel illustrations of how nonlinear effects and dynamics can be fruitfully modelled and applied. These examples dovetailed nicely with the key reasons why we believe modelling nonlinear effects and dynamics are so important for advancing our understanding of close relationships, including (I) testing nonlinear theoretical assumptions, (II) reconciling inconsistencies and revealing novel effects, (III) detecting dynamics shifts in core relationship constructs, and (IV) capturing temporal and spatial synchrony between partners within dyads. We hope that these examples prove useful to scholars as they consider the new ways in which nonlinearity can be applied to their own scientific work and help advance relationship science.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Yuthika U. Girme https://orcid.org/0000-0002-0059-2144
Nickola Overall https://orcid.org/0000-0002-9703-4383
Jeffry A. Simpson https://orcid.org/0000-0003-1899-2493

References

Arriaga, X. B. (2001). The ups and downs of dating: Fluctuations in satisfaction in newly formed romantic relationships. *Journal of Personality and Social Psychology*, *80*(5), 754–765. https://doi.org/10.1037/0022-3514.80.5.754

Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007). Psychology as the science of self-reports and finger movements: Whatever happened to actual behavior? *Perspectives on Psychological Science*, *2*(4), 396–403. https://doi.org/10.1111/j.1745-6916.2007.00051.x

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. Guilford Press.

Butler, E. A., & Barnard, K. J. (2019). Quantifying interpersonal dynamics for studying socio-emotional processes and adverse health behaviors. *Psychosomatic Medicine*, *81*(8), 749–758. https://doi.org/10.1097/psy.0000000000000703

Chopik, W. J., Newton, N. J., Ryan, L. H., Kashdan, T. B., & Jarden, A. J. (2019). Gratitude across the life span: Age differences and links to subjective well-being. *The Journal of Positive Psychology*, *14*(3), 292–302. https://doi.org/10.1080/17439760.2017.1414296

*Chopik, W. J., Weidmann, R., Oh, J., & Purol, M. F. (2022). Grateful expectations: Cultural differences in the curvilinear association between age and gratitude. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075211054391

Cook, W. L., & Kenny, D. A. (2005). The actor–partner interdependence model: A model of bidirectional effects in developmental studies. *International Journal of Behavioral Development*, *29*(2), 101–109. https://doi.org/10.1080/01650250444000405

Don, B. P., Roubinov, D. S., Puterman, E., & Epel, E. S. (2022). The role of interparental relationship variability in parent-child interactions: Results from a sample of mothers of children with autism spectrum disorder and mothers with neurotypical children. *Journal of Marriage and Family*, *84*(4), 982–1001. (in press) https://doi.org/10.1111/jomf.12852

*Dugan, K. A., Fraley, R. C., Gillath, O., & Deboeck, P. R. (2022). Changes in global and relationship-specific attachment working models. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075211051408

Eastwick, P. W., Finkel, E. J., & Simpson, J. A. (2019). Relationship trajectories: A meta-theoretical framework and theoretical applications. *Psychological Inquiry*, *30*(1), 1–28. https://doi.org/10.1080/1047840x.2019.1577072

Eller, J., Girme, Y. U., Don, B. P., Rholes, W. S., Mickelson, K. D., & Simpson, J. A. (in press) Here one time, gone the next: Fluctuations in support received and provided predict changes in relationship satisfaction across the transition to parenthood. *Journal of Personality and Social Psychology.*

*Eller, J., Magro, S. W., Roisman, G. I., & Simpson, J. A. (2022). The predictive significance of fluctuations in early maternal sensitivity for secure base script knowledge and relationship effectiveness in adulthood. *Journal of social and Personal Relationships*. Advanced online publication. doi: https://doi.org/10.1177/02654075221077640

Gable, S. L., & Reis, H. T. (1999). Now and then, them and us, this and that: Studying relationships across time, partner, context, and person. *Personal Relationships*, *6*(4), 415–432. https://doi.org/10.1111/j.1475-6811.1999.tb00201.x

Girme, Y. U. (2020). Step out of line: Modeling nonlinear effects and dynamics in close-relationships research. *Current Directions in Psychological Science*, *29*(4), 351–357. https://doi.org/10.1177/0963721420920598

Girme, Y. U., Agnew, C.R., VanderDrift, L. E., Harvey, S. M., Rholes, W. S., & Simpson, J. A. (2018). The ebbs and flows of attachment: Within-person variation in attachment undermine relationship wellbeing across time. *Journal of Personality and Social Psychology*, *114*(3), 397–421. https://doi.org/10.1037/pspi0000115

Girme, Y. U., Jones, R. E., Fleck, C., Simpson, J. A., & Overall, N. C. (2021b). Infants' attachment insecurity predicts attachment-relevant emotion regulation strategies in adulthood. *Emotion*, *21*(2), 260–272. https://doi.org/10.1037/emo0000721

Girme, Y. U., Overall, N. C., Simpson, J. A., & Fletcher, G. O. (2015). All or nothing": Attachment avoidance and the curvilinear effects of partner support. *Journal of Personality and Social Psychology*, *108*(3), 450–475. https://doi.org/10.1037/a0038866

Girme, Y. U., Peters, B. P., Baker, L. R., Overall, N. C., Fletcher, G. J. O., Reis, H. T., Jamieson, J. P., & Sigal, M. (2021a). Attachment anxiety and the curvilinear effect of expressive suppression on individuals' and partners' outcomes. *Journal of Personality and Social Psychology*, *121*(3), 524–547. https://doi.org/10.1037/pspi0000338

Gottman, J. M. (2002). *The mathematics of marriage: Dynamic nonlinear models*. MIT Press.

Gottman, J. M., & Notarius, C. I. (2000). Decade review: Observing marital interaction. *Journal of Marriage and Family*, *62*(4), 927–947. https://doi.org/10.1111/j.1741-3737.2000.00927.x

Gunaydin, G., Selcuk, E., Urganci, B., & Yalcintas, S. (2021). Today you care, tomorrow you don't: Differential roles of responsiveness variability and average responsiveness in romantic attachment. *Social Psychological and Personality Science*, *12*(5), 839–849. https://doi.org/10.1177/1948550620944111

Holt-Lunstad, J. (2018). Why social relationships are important for physical health: A systems approach to understanding and modifying risk and protection. *Annual Review of Psychology*, *69*(1), 437–458. https://doi.org/10.1146/annurev-psych-122216-011902

Kelley, H. H., Holmes, J. G., Kerr, N. L., Reis, H. T., Rusbult, C. E., & Van Lange, P. A. (2003). *An atlas of interpersonal situations*. Cambridge University Press.

Kelley, H. H., & Thibaut, J. W. (1978). *Interpersonal relations: A theory of interdependence*. Wiley.

Kenny, D. A., Kashy, D. A., & Cook, W. L. (2020). *Dyadic data analysis*. Guilford Publications.

*Kuelz, A., Boyd, S., & Butler, E. (2022). Close ties in relationships: A dynamic systems approach for modeling physiological linkage. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075221082594

*Lafit, G., Sels, L., Adolf, J. K., Loeys, T., & Ceulemans, E. (2022). PowerLAPIM: An application to conduct power analysis for linear and quadratic longitudinal actor–partner interdependence models in intensive longitudinal dyadic designs. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075221080128

Muise, A., Schimmack, U., & Impett, E. A. (2016). Sexual frequency predicts greater well-being, but more is not always better. *Social Psychological and Personality Science*, *7*(4), 295–302. https://doi.org/10.1177/1948550615616462

*Ogolsky, B. G., Mejia, S. T., Chronopoulou, A., Dobson, K., Maniotes, C. R., Rice, T. M., Hu, Y., Theisen, J. C., & Carvalho Manhães Leite, C. (2021). Spatial proximity as a behavioral marker of relationship dynamics in older adult couples. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075211050073

Overall, N. C. (2020). Behavioral variability reduces the harmful longitudinal effects of partners' negative-direct behavior on relationship problems. *Journal of Personality and Social Psychology*, *119*(5), 1057–1085. https://doi.org/10.1037/pspi0000231

Overall, N. C., Fletcher, G. J., & Friesen, M. D. (2003). Mapping the intimate relationship mind: Comparisons between three models of attachment representations. *Personality & Social Psychology Bulletin*, *29*(12), 1479–1493. https://doi.org/10.1177/0146167203251519

Overall, N.C., Girme, Y. U., & Simpson, J. A. (2016). The power of diagnostic situations: How support and conflict can foster growth and security. In C.R. Knee, & H.T. Reis (Eds), *Positive approaches to optimal relationship development* (pp. 148–169). Cambridge University Press.

Robles, T. F., Slatcher, R. B., Trombello, J. M., & McGinn, M. M. (2014). Marital quality and health: A meta-analytic review. *Psychological Bulletin*, *140*(1), 140–187. https://doi.org/10.1037/a0031859

*Sels, L., Schat, E., Verhofstadt, L., & Ceulemans, E. (2022). Introducing change point detection analysis in relationship research: An investigation of couples' emotion dynamics. *Journal of Social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075211070558

Simpson, J. A., Rholes, W. S., Campbell, L., & Wilson, C. L. (2003). Changes in attachment orientations across the transition to parenthood. *Journal of Experimental Social Psychology*, *39*(4), 317–331. https://doi.org/10.1016/s0022-1031(03)00030-1

Solomon, D. H., & Knobloch, L. K. (2004). A model of relational turbulence: The role of intimacy, relational uncertainty, and interference from partners in appraisals of irritations. *Journal of Social and Personal Relationships*, *21*(6), 795–816. https://doi.org/10.1177/0265407504047838

*Solomon, D. H., Jones, S., Brinberg, M., Bodie, G. D., & Ram, N. (2022). Using sequence analysis to identify conversational motifs in supportive interactions. *Journal of social and Personal Relationships*. Advanced online publication. https://doi.org/10.1177/02654075211066618

*papers that appear in this special issue.