

Daily Implications of Felt Love for Sleep Quality

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This study introduces the concept of felt love as the monadic experience of love, a parallel of dyadic love, and presents a study examining the relationships between daily felt love and sleep quality across 28 days. Before beginning the daily protocol, participants answered 60 questions assessing common situations that may make people feel loved. These questions were used to establish a consensus on the meaning of felt love for the specific participants under study. During the daily life study, participants ($N = 52$) provided self-reports via smartphone surveys for 28 days. Each morning upon waking, participants assessed their subjective sleep quality, and each evening positive affect was assessed with a set of 5 questions. Participants also rated how much they felt loved at 6 semirandom times throughout the day. Felt love measures were aggregated to obtain daily means and individual means across the study. Variability in felt love was quantified by calculating within-day and between-day standard deviations. Multilevel modeling was used to account for repeated measurements for each participant across the study, and the final model includes age, sex, positive affect, and felt love as predictors of sleep quality. Participants who reported higher positive affect and higher within-day felt love variability reported better overall sleep quality. However, overall mean levels of felt love did not significantly predict sleep quality, nor were there effects at the daily level. These results suggest that experiencing a range of felt love intensities within an average day is associated with better sleep quality.

KEYWORDS: felt love, sleep quality, positive affect, ecological momentary assessment, EMA

Love can be defined as an emotion that is felt in any context in which people are making connections with one another (Izard, 1977). Not only is love experienced in this specific context, but love is also said to foster connectedness (Cavanaugh, Bettman, & Luce,

2015). In the current study, we focus on participants' subjective one-sided experience of being loved—felt love—which we distinguish from the related concepts of dyadic love and romantic love. Dyadic love, or love that is shared between two members of a dyad, is

dependent on shared feelings of both parties involved in the expression and reception of love. In contrast, felt love focuses only on the receiver's understanding and interpretation of an expression as loving. Felt love is further differentiated from the related construct of romantic love, which is a particular type of dyadic love said to serve the particular purpose of promoting long-term commitment, although the specific definition may vary by culture (see Gonzaga, Turner, Keltner, Campos, & Altemus, 2006 for more discussion). Felt love is highlighted as a component of these related constructs, although it may also occur in other contexts.

Previous research on this view of love examined whether there is a shared belief on what it means to "feel loved" from the receiver's perspective in a study of American participants and found that there indeed is a consensus among Americans on indicators of felt love, which includes both romantic and nonromantic contexts (Oravecz, Muth, & Vandekerckhove, 2016). Felt love in daily life has a significant impact on psychological well-being when examined on a day-to-day basis (Oravecz, Dirsmith, Heshmati, Vandekerckhove, & Brick, 2020). However, to our knowledge little research has focused on the implications of experiences of daily felt love on physical health indicators such as sleep quality. The present study aims to extend prior research by first establishing a cultural consensus on felt love in our sample and then examining the relationship between participants' subjective experiences of felt love and sleep quality in daily life.

What Is Felt Love?

Fredrickson (2016) posited that love results from a specific state called positivity resonance between individuals, which is necessarily described in the context of a dyad. Felt love constitutes the one-sided subjective experience of positivity resonance, which should therefore be considered a required element of dyadic love. Fredrickson's framework presents three dyadic elements that are required for positivity resonance from which feelings of love originate: bibehavioral synchrony, shared momentary experiences of positive emotion, and mutual care. Felt love encompasses the following monadic analogs of each of these core elements: a bibehavioral response, a feeling of positive change in emotion, and the perception of outside care or investment in one's well-being.

Although felt love is often thought to be experienced in situations directly involving two or more people, it may exist in other contexts. For example, it may linger after a dyadic encounter (e.g., after a conversation with a friend or romantic partner), or it may be indirect and occur without the explicit participation of the other participant (e.g., overhearing a conversation). The effects of these experiences of felt love also need not end at the conclusion of the experience but may have a lasting influence on a person's emotional state, overall well-being, and health behaviors and outcomes.

Two prior studies (Heshmati et al., 2019; Oravecz et al., 2016) examined whether there is a shared belief among American samples on what it means to "feel loved" from the receiver's perspective. These studies established a cultural consensus on the definition of felt love in large representative American samples by having participants complete a large set of items that ask them to rate whether most people would feel loved in each of the different scenarios (see Heshmati et al., 2019, for further description). Results from these prior studies indicate that there indeed is a consensus on indicators of felt love, which includes both romantic and nonromantic contexts as well as situations that are not necessarily dyadic (e.g., religion, nature; Heshmati et al., 2019; Oravecz et al., 2016).

Felt Love and Sleep Quality

Sleep quality has important implications for performance and experience across the life span. For example, better sleep quality is associated with better school performance for children and adolescents (Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010). Poor sleep quality is associated with outcomes such as lower well-being and increased feelings of anger and fatigue in college students (Pilcher, Ginter, & Sadowsky, 1997). In middle-aged and older adults, poor subjective sleep quality predicts higher levels of inflammatory markers (Friedman, 2011) and is associated with impaired performance on cognitive measures in older adults (Miyata et al., 2013; Nebes, Buysse, Halligan, Houck, & Monk, 2009).

Within an individual, sleep quality also has influences at much faster time scales. For example, Bower, Bylsma, Morris, and Rottenberg (2010) found that sleep quality over the past month is predictive of

momentary positive affect after accounting for symptoms of depression and anxiety, although the effect of sleep quality on negative affect was nonsignificant after depression status was accounted for. Scott and Judge (2006) showed that over the course of 3 weeks, insomnia on a given night predicts more hostility and fatigue in the workplace and less positivity at work the next day. Age and gender also influence sleep and are common control variables in other studies of sleep quality (Bower et al., 2010; Dewald et al., 2010; Friedman, 2011; Major, Le Nguyen, Lundberg, & Fredrickson, 2018; Scott & Judge, 2006).

Although the effects of felt love on psychological well-being in daily life have been studied (Oravecz et al., 2020), the association between felt love and sleep quality has not been. Another study highlighted that although theories would suggest love to be a construct that varies on a momentary basis, the number of studies that measure love in this manner is limited (Coffey, Xia, & Fosco, 2020). Furthermore, the literature evaluating the relationship between sleep quality and being in love or experiencing romantic love has shown mixed results. For example, in a sample of Iranian female adolescents, those who reported being in love also reported higher positive mood, but no association was found between being in love and sleep quality (Bajoghli, Joshaghani, Mohammadi, Holsboer-Trachsler, & Brand, 2011). However, being in love was associated with better sleep quality and with more positive mood in both the morning and the evening in an adult sample (Bajoghli et al., 2014). We propose that in order to understand the link between daily love experiences and sleep quality, it is more useful to look at felt love stemming from a broader range of experiences than to look at romantic love in isolation.

Although the literature on felt love and sleep quality is small, other studies have examined more generally the effects of positive affect and emotions on sleep quality. A review paper by Ong, Kim, Young, and Steptoe (2017) listed ambulatory studies examining these associations, with some finding associations between daytime positive affect and sleep quality the next night (Fuligni & Hardway, 2006; Galambos, Dalton, & Maggs, 2009; Ong et al., 2013; Song, Graham-Engeland, Mogle, & Martire, 2015). Based on these prior findings, we propose to examine the effects of felt love on sleep quality to further understand

whether daily experiences of felt love, above and beyond other positive affect, is predictive of people's sleep quality in the next night.

The Current Study

In the present study we first sought to replicate results from Heshmati et al. (2019) and Oravecz et al. (2016) and thus derived the cultural consensus among our sample in terms of what constitutes felt love. Given the consensus on experiences of love in our sample, we examined the relationship between daily levels of felt love and sleep quality, at both the between- and within-person levels. We studied the following main hypotheses: first, that felt love is predictive of better sleep quality, above and beyond the influence of positive affect, and while controlling for age and sex; and second, that greater consistency in felt love across time predicts better sleep quality. An ecological momentary assessment (EMA; Shiffman, Stone, & Hufford, 2008; Smyth & Stone, 2003) design was used to assess how loved participants felt at randomly spaced times throughout each day of the study as a means of quantifying feelings of love in everyday life, and participants reported on their sleep quality as part of the first assessment each day.

Part of the data analyzed here was also used by Oravecz and Vandekerckhove (2020) as an empirical application to illustrate a joint statistical model of cognitive and emotional experiences that was developed in their article. However, the focus of that analysis and the corresponding research questions were different from the ones in the current study.

STUDY

METHODS

Participants

The study's sample consisted of 52 participants (35 female, mean age = 30 years, $SD = 10$, range = 19–65) recruited on the campus of a large northeastern university in the United States over the summer. Most participants were White (80%), with smaller percentages for other ethnicities (Asian, 10%; Black, 4%; and Hispanic, 6%), and highly educated: 27% of the participants held master's degrees or above, 36% had bachelor's degrees, and the remaining 37% had college degrees.

Procedure

Participants were informed that the study protocol consisted of filling out six semirandomly spaced short web-based surveys (Qualtrics, 2005) on their own smartphones each day for 28 days while living their regular daily lives and completing demographic items and a battery of psychological questionnaires during two lab sessions (introductory and exit). After consent, the participants provided their phone numbers and were registered with the SurveySignal text messaging service (Hofmann & Patel, 2015). The short surveys started the day after the introductory session. Participants were paid in proportion to their response rate, with maximum payment of US\$200. During the study, 168 daily web survey prompts were sent to each participant. Compliance was high: The mean number of responses was 157 ($SD = 15$). Survey prompts were timed by asking each participant to report their usual waking hours on typical weekday and weekend days and dividing those hours into six blocks. Survey prompts were scheduled once per block, subject to the constraint that no two surveys were presented within a half hour of each other. This study was approved by the institutional review board.

Measures

FELT LOVE QUESTIONNAIRE.

At the introductory in-laboratory interview participants completed a battery of 60 items (Heshmati et al., 2019) that asked them to report on whether they think most people would feel loved in each situation. Instructions told participants that the questions were not about their own opinions or experiences, but they were instead supposed to report on whether they thought most people would feel loved in those situations. The items were daily scenarios that had the potential to make people feel loved and were centered on seven themes: trust and acceptance, support in needs and goals, symbolic or physical expressions, sharing time with others, other possible sources of love such as nature and pets, controlling behavior from others, and some neutral items as controls, as described in Heshmati et al. (2019, p. 224). Response options for all questions included “True,” “False,” and “Don’t Know.”

DAILY SLEEP QUALITY.

Participants were asked each morning about the quality of their previous night’s sleep via the item, “Overall, how well did you sleep last night?” which was adapted from the Pittsburgh Sleep Quality In-

dex (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) for daily use. They rated this item on a sliding scale ranging from 0 to 100, corresponding with endpoints *Not well* and *Very well*, respectively. This item is similar to other single-item subjective sleep quality assessments used in daily diary studies (Hülshager et al., 2014; Kühnel, Bledow, & Feuerhahn, 2016; Sonntag, Binnewies, & Mojza, 2008; Tracy et al., 2018; van Eerde & Venus, 2018). Days were excluded if sleep quality was not reported.

DAILY POSITIVE AFFECT.

At the end of each day, participants filled out the SPANE questionnaire, which included 12 items assessing positive and negative affect (Diener et al., 2010). Each of these items was assessed on a 0–100 scale. Because we were interested only in positive affect, we calculated a mean score of the six positive affect items for each participant on each day of the study. This daily positive affect measure was centered around participants’ individual-specific means (*iMean*) across all 28 days, in order to capture the deviation of each day’s positive affect from a “typical” day’s positive affect for each participant. Days were excluded if participants did not answer the SPANE questionnaire.

DAILY FELT LOVE AND FELT LOVE VARIABILITY.

Six times per day, participants were asked the degree to which they felt loved via the item, “How much do you feel loved right now?” Two day-level measures were computed from these responses: a day-level mean, here called daily felt love, which captures the overall amount of felt love experienced throughout the day, and a within-day standard deviation, called within-day felt love variability, which captures the amount of variability in felt love experienced during that same day. Individual-specific means (*iMeans*) were calculated for both felt love and felt love variability across the study to capture individuals’ “typical” levels of felt love and “typical” amounts of variability in felt love. The day-level felt love and felt love variability measures were centered around participants’ *iMeans* in order to capture the deviation of each day from a “typical” day for each individual. For completeness, between-day felt love variability, the standard deviation of daily felt love across all days for a given participant, was also calculated to capture the day-to-day (as opposed to within-day) variation in felt love at the person level. It was expected that both a higher overall level of felt love and greater consistency in felt love over time would improve sleep quality.

Days were excluded if participants had fewer than two measurements of felt love.

COVARIATES.

In each of the models, age and sex (coded -1 = female; 1 = male) were included as covariates to test the effects of our predictors of interest on sleep quality, above and beyond the effects of age and sex. Both items were assessed during an introductory survey and treated as time-invariant covariates in all models.

Data Analysis

CULTURAL CONSENSUS THEORY ANALYSIS.

Before testing our hypothesis on felt love and sleep quality, we used the Extended Condorcet Model (Oravecz, Faust, & Batchelder, 2014; Oravecz, Faust, Batchelder, & Levitis, 2015) to establish whether there was a consensus on the meaning of felt love among participants. This model comes from the cultural consensus theory (CCT) framework and can be used to study both consensus on items tapping into a shared domain (e.g., questions related to everyday felt love experiences) and individual differences in decision making related to these items (e.g., cultural competency in terms of knowing the consensus). The model was fitted to participants' responses on the 60 felt love scenarios via the Hierarchical Condorcet Modeling Toolbox¹ (Batchelder, Anders, & Oravecz, 2018).

DAILY LIFE STUDY ANALYSIS.

For statistical testing of our hypothesis we chose the multilevel modeling (Raudenbush & Bryk, 2002) approach, because it provides a principled statistical framework for modeling nested data from multiple participants. Two of the four computed statistics listed above are between-person predictors: felt love iMean and between-day felt love variability. The remaining two are within-person predictors: daily felt love and within-day felt love variability. The individual means of each of the predictors were sample centered so that the intercept reflects a prototypical participant.

Model 1 is a restricted model in which sleep quality each day (day level) is predicted based on age and sex. This model provided initial variance estimates at the within-person level (day level) and the between-person level (person level). Model 2 added predictors quantifying the positive affect iMeans (person level) and daily positive affect (day level), including a random effect for day level positive affect. Finally, Model 3 included felt love iMeans (person level) and daily felt love (day level) with random effects for the day level predictor (daily felt love). Model 3 also included

iMeans, daily mean levels for daily felt love variability and a random effect for day level felt love variability, and an individual standard deviation (iSD) quantifying the average between-day variability in felt love at the person level.

Formally, the three models are specified as

$$\begin{aligned}
 \text{SleepQuality}_{i,t} = & \frac{\overbrace{\gamma_{00} + \gamma_{01}\text{Age}_i + \gamma_{02}\text{Sex}_i + u_{0i} + e_{it}}^{\text{Predictors in Models 1,2,3}}}{\overbrace{\gamma_{03}\text{PositiveAffect}_i + \gamma_{10}\text{PositiveAffect}_{it} + u_{1i}\text{PositiveAffect}_{it}}^{\text{Predictors in Models 2,3}}} \\
 & + \frac{\overbrace{\gamma_{04}\text{DailyFeltLove}_i + \gamma_{20}\text{DailyFeltLove}_{it} + u_{2i}\text{DailyFeltLove}_{it}}^{\text{Predictors in Model 3}}}{\overbrace{\gamma_{05}\text{FeltLoveWithinDaySD}_i + \gamma_{30}\text{FeltLoveWithinDaySD}_{it}}^{\text{Predictors in Model 3}}} \\
 & + \frac{\overbrace{u_{3i}\text{FeltLoveWithinDaySD}_{it}}^{\text{Predictors in Model 3}}}{\overbrace{\gamma_{06}\text{FeltLoveBetweenDaySD}_i}^{\text{Predictors in Model 3}}}
 \end{aligned}$$

where $\text{SleepQuality}_{i,t}$ is the sleep quality reported by individual i on day t ; γ_{00} is the expected sleep quality score for a prototypical person on a prototypical day; γ_{01} and γ_{02} are the (fixed) effects of our covariates age and sex on sleep quality; γ_{03} , γ_{04} , γ_{05} , and γ_{06} are the fixed effects of the iMeans (or person means) of positive affect, daily felt love, and within- and between-day felt love variability; γ_{10} , γ_{20} , and γ_{30} are the fixed effects of the day level predictors (positive affect, daily felt love, and within-day felt love variability); u_{0i} is the random intercept term, and u_{1i} , u_{2i} , and u_{3i} are the random effects of the day level predictors. At each level in the model-building process, models were compared via the Akaike information criterion (AIC), log-likelihood, and χ^2 statistics, where lower values of each statistic suggest better model fit. The significance of this improvement in fit is tested statistically via a χ^2 test, where a significant result indicates a significant improvement in fit.

In line with our hypotheses, we expected the felt love predictors (γ_{04} , γ_{05} , and γ_{06} in the model) to be positively associated with sleep quality. We further expected that the daily mean level predictors (γ_{10} , γ_{20} , and γ_{30}) would be positively associated with sleep quality on a day-to-day level. All analyses were performed in R version 3.4.1 "Single Candle" (R Core Team, 2017) in the psych (Revelle, 2017), MuMIn (Bartoń, 2018), and tidyverse (Wickham, 2017) packages. Multilevel models were run in the nlme (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2017) package. A power analysis via simr (Green & MacLeod, 2016), given our sample size and an approximate effect size of 0.3, showed greater than 80% power to detect our primary fixed effect. We therefore consider our sample size to be sufficient. All data and scripts are available from the Open Science Framework (https://osf.io/5c3xp/?view_only=87288813b1464801a6ba74fe5278c835).

RESULTS

Cultural Consensus Model Results

Consensus estimates for each of the 60 felt love items were derived from the Extended Condorcet Model. As shown by Oravecz and Vandekerckhove (2020) in a CCT analysis of the same data, there is a single consensus in our sample on what constitutes felt love. The first eigenvalue output by the model was roughly six times as large as the second eigenvalue, with minimal differences in subsequent eigenvalues. This indicates that the majority of variance in responses to the felt love items is explained by a single dimension, and thus we can conclude that there is a single consensus in our sample on the meaning of felt love. We present further results below not discussed by Oravecz and Vandekerckhove (2020) to highlight example situations that participants agree convey felt love.

Results from the CCT analysis are presented in Table 1 for 10 sample items (see the Appendix for full list of items and results). It is important to note that the items were coded as 0 for “False” and 1 for “True.” The sample items were chosen to provide items for which the consensus answer was “True” (top five rows in Table 1) and some items for which the consensus answer was “False” (bottom 5 rows in Table 1). In the third column, a true/false mean value (across participants) closer to 1 indicates that the consensus for that item is “True” and a mean value

closer to 0 indicates that the consensus is “False.” Overall, participants agreed that 45 out of the 60 felt love items represented situations that would make one feel loved, as indicated by the true/false mean and corresponding consensus label in the table. There was little disagreement or uncertainty among participants in the consensus answers, as evidenced by the true/false means, which for all items were close to either 0 or 1 (see true/false mean in the third column of Table 1 and the Appendix). Item difficulty estimates and ranks relate to the level of knowledge about the cultural consensus needed to answer the question in line with the consensus. Negative item difficulties indicate items that were easy to know the consensus on for a person with an average level of consensus knowledge, and positive items indicate items that were more difficult. Item difficulty ranks are presented in descending order, such that the most difficult item to answer receives a rank of 1 and the least difficult item to answer receives a rank of 60. For example, items 2 and 11 (“They feel accepted” and “They feel appreciated”) have very low item difficulties, indicating that they are easier items to answer.

Some of the items that participants agreed constitute love include “Someone is there just to listen,” “They are around people, having fun,” “Someone shows compassion towards them in difficult times,” “They feel accepted,” “They feel appreciated,” “They feel connected to god,” and “They attend a re-

TABLE 1. Extended Condorcet Model Consensus Results

Item no.	Item	True/false mean	Consensus label	Item difficulty	Item difficulty rank
2	They feel accepted	1.00	True	-1.64	49
6	They feel connected to god	1.00	True	-0.13	32
11	They feel appreciated	1.00	True	-1.68	53
25	They attend a religious ceremony	0.99	True	2.30	8
41	Someone shows compassion towards them in difficult times	1.00	True	-0.85	39
7	They play sports	0.00	False	0.24	26
8	The sun is shining	0.00	False	1.48	13
9	Someone tells them what is best for them	0.00	False	0.99	17
28	Someone else wants to know where they are at all times	0.00	False	0.91	19
54	They feel close to nature	0.01	False	2.50	6

Note. Item numbers refer to the order in which the items were presented on the questionnaire. Item difficulty and true/false mean are rounded to 2 decimal points. Item difficulty ranks were established before rounding of item difficulty. Negative item difficulties indicate items that were much easier to answer, and positive items indicate items that were more difficult to answer.

ligious ceremony.” Situations that participants agree do not constitute felt love include “They play sports,” “The sun is shining,” and “They feel close to nature.” This helps to distinguish felt love from positive affect because these situations may make people have positive feelings, but these positive feelings are distinct from felt love. In addition, participants agreed that controlling behavior from others does not constitute felt love (e.g., “Someone else wants to know where they are at all times” and “Someone tells them what is best for them”).

Multilevel Modeling Results

As validation of our decision to take a multilevel modeling approach, we calculated the intraclass correlation for sleep quality ($ICC = .30$). The ICC explains the proportion of sleep quality variance that can be explained by mean differences across participants. Here, the ICC is 30%, meaning that the remaining 70% of variance is at the within-person level. This indicates that there is variance to be explained at both levels and suggests that a multilevel model may be appropriate.

During the multilevel model building process, models were compared at each step via AIC, log-likelihood, and χ^2 statistics, where lower values indicate better fit. By these conventions (Table 2), the final model, which included age, sex, positive affect, and both mean felt love and felt love variability, had the best fit for the data, accounting for about 35% of the variability in sleep quality. The restricted model, which contained only effects of sex and age, explained 30% of the variability in sleep quality, and the model containing the effects of sex, age, and positive affect explained 33% of the variability in sleep quality. Follow-up analyses revealed that both mean and variability of felt love each contribute almost their full value to the final model, implying that they do not overlap in the variance they explain and that

each brings its own unique predictive information. This indicates that although the effect of felt love on sleep quality is small, it is about the same size in prediction terms as the effect of positive affect, and its persistence as a significant effect after controlling for positive affect implies that felt love has an influence on sleep quality that is both statistically significant and not totally mediated by positive affect.

Coefficient estimates from the final model are shown in Table 3. Tests of the interactions in each model were found to be not statistically significant; these results are therefore not reported here, and no interactions were carried forward into later models. The level of sleep quality for a prototypical person is $\gamma_{00} = 69.53$ ($SE = 4.84$) with substantial between-person differences ($\sigma_{u0} = 9.68$). The within-person fixed effect of positive affect was not statistically significant ($\gamma_{10} = 0.12, p = .065$) although there are significant between-person differences in this association ($\sigma_{u1} = 0.22$). The fixed effects for daily felt love ($\gamma_{20} = 0.08, p = .449$) and felt love variability ($\gamma_{30} = -0.05, p = .676$) were also not statistically significant, but there was considerable variation in these relationships across participants ($\sigma_{u2} = 0.36, \sigma_{u3} = 0.39$). At the between-person level, mean daily felt love was not associated with sleep quality ($\gamma_{04} = 0.32, p = .052$). However, participants who showed higher average within-day variability in felt love reported sleeping better at night ($\gamma_{05} = 1.33, p = .025$). Figure 1 depicts the effects of mean daily felt love and felt love variability on sleep quality at the between-person level.

To better understand the between-person effects of mean levels and variability in felt love, we explored the interaction between these variables but found them to be not statistically significant. However, it is interesting to note that for participants with higher mean levels of felt love, higher levels of between-day variability in felt love tend to be negatively associated with sleep quality, and for participants with lower

TABLE 2. Model Comparison

	Akaike information criterion	-2 Log likelihood	χ^2	<i>p</i>	<i>R</i> ²	Degrees of freedom
Age/sex	8,683.03	8,673.03			.30	
Age/sex/positive affect	8,656.17	8,638.17	34.86	<.001	.33	9
Age/sex/positive affect/love	8,657.96	8,615.96	22.21	.035	.35	21

TABLE 3. Multilevel Modeling Results for Final Model

Fixed effects	Estimate	SE	95% Confidence interval	p
Intercept (γ_{00})	69.53	4.84	[60.08, 78.99]	<.001
Age _i (γ_{01})	-0.09	0.15	[-0.40, 0.21]	.543
Sex _i (γ_{02})	-0.54	3.23	[-7.04, 5.94]	.866
PositiveAffect _{it} (γ_{10})	0.12	0.07	[-0.01, 0.25]	.065
PositiveAffect _i (γ_{03})	0.37	0.15	[0.06, 0.68]	.021
FeltLove _{it} (γ_{20})	0.08	0.10	[-0.12, 0.27]	.449
FeltLove _i (γ_{04})	0.32	0.16	[-0.00, 0.65]	.052
FeltLoveWithinDaySD _{it} (γ_{30})	-0.05	0.13	[-0.31, 0.20]	.676
FeltLoveWithinDaySD _i (γ_{05})	1.33	0.57	[0.18, 2.48]	.025
FeltLoveBetweenDaySD _i (γ_{06})	-1.25	0.79	[-2.83, 0.33]	.119
Random effects				
Residual (σ)	19.34		[18.42, 20.30]	
Intercept (u_{0i})	9.68		[7.64, 12.29]	
PositiveAffect _{it} (u_{1i})	0.22		[0.11, 0.44]	
FeltLove _{it} (u_{2i})	0.36		[0.19, 0.68]	
FeltLoveWithinDaySD _{it} (u_{3i})	0.39		[0.14, 1.07]	

Note. $N = 52$.

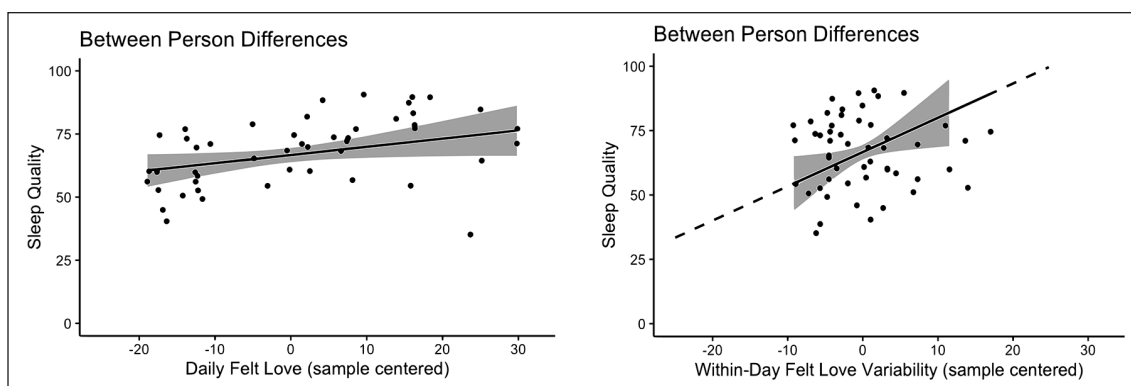


FIGURE 1. Effects of mean daily felt love and felt love variability on sleep quality. Between-person effects of daily felt love (left) and within-day felt love variability (right) on sleep quality. Shaded areas indicate 95% confidence intervals. Dashed lines extend the linear relationship beyond the observed range of values to allow comparison of the two plots

mean levels of felt love, this association appears to be much weaker. In contrast, for participants with higher mean levels of felt love, higher levels of within-day variability in felt love tend to be positively associated with sleep quality, and for participants with lower mean levels of felt love, this association appears to be weaker. Although no conclusions can be drawn from

these data, this pattern suggests that experiencing greater variability may have stronger implications for sleep quality for people with generally high levels of felt love. When these interactions are included in the model, the overall pattern of results reported above does not change significantly. These results are depicted in Figure 2.

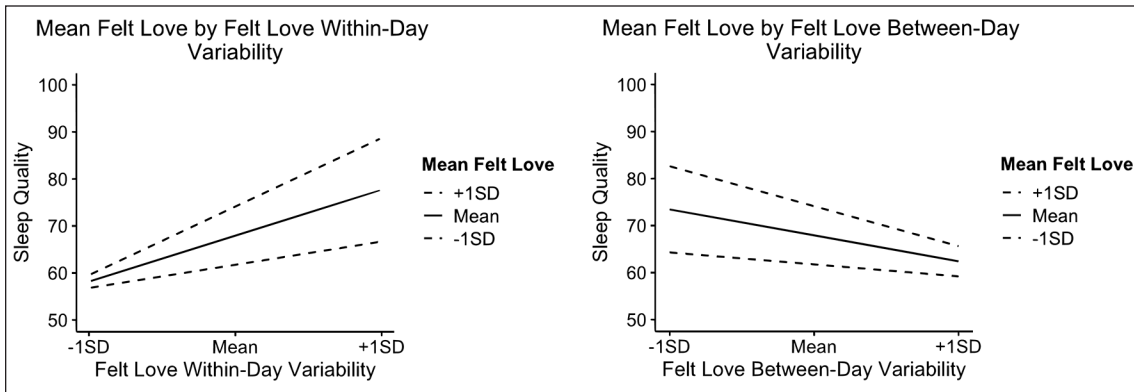


FIGURE 2. Interaction effects. Interaction plots to show association between mean and variability levels of felt love. For within-day variability in felt love (left), higher variability results in higher sleep quality across all mean levels of felt love, but this association appears to be especially strong for participants with higher mean levels of felt love. For between-day variability in felt love (right), higher variability results in lower sleep quality across all mean levels of felt love, but this association appears to be especially strong for participants with higher mean levels of felt love

DISCUSSION

The primary goal of this study was to examine the links between felt love and sleep quality in everyday life. Felt love is defined as a construct representing the one-sided subjective experience of love in daily life, which was conceptualized as a monadic form of positivity resonance probably involving a biobehavioral response, positive change in emotionality, and the perception of outside investment in one's well-being. We first established consensus among participants in our sample regarding what constitutes felt love for them by using a baseline felt love questionnaire. Situations that participants agreed would make people feel loved fell into a number of categories including trust and acceptance, support in needs and goals, symbolic and physical expressions, and sharing time with others. Participants agreed that the remaining 15 items did not constitute felt love; these items generally fell into two main categories: controlling behavior from others and items that generally evoke positive feelings but not love (e.g., playing sports).

Then in the daily life study, we hypothesized that felt love would be predictive of better sleep quality above and beyond positive affect and the covariates of age and sex and that greater consistency (and therefore less variability) in felt love would be associated with better sleep quality. Results from multi-level models indicate that participants who reported higher levels of positive affect reported better sleep

quality. In addition, and contrary to hypotheses, participants who reported greater average within-day variability in felt love reported better sleep quality. However, after the between-person effect of positive affect on sleep quality was accounted for, there was no statistically significant between-person effect of mean level of felt love. Together, the significant between-person effect of within-day variability in felt love and the nonsignificance of the between-person effect of mean levels of felt love suggest that it is not mean levels of love but its variations that are more strongly linked with sleep quality. We also found no effect of day-to-day variability in felt love on sleep quality.

Although it is not immediately clear why greater variability in felt love within a day is associated with better sleep, it is possible that feeling too much love constantly could make people take less notice or be less appreciative of the love they receive from others. Indeed, previous research has shown that greater habituation occurs with repeated positive stimuli than with negative stimuli (Wright et al., 2001), suggesting that too much consistency in felt love may have a weaker influence over time. However, these effects may be more complex than habituation. The hedonic treadmill theory (Brickman & Campbell, 1971) suggests that perhaps it is not the level of felt love that is important but rather the increase in felt love that makes a difference. Boker and Laurenceau (2006) argued that not only is change important, but the timing of change may also carry meaning. For example, a

person whose support network expresses love more strongly in response to a variable need for loving feelings would have more variation in felt love than one with a less attuned network; these types of influences may be driving the effect. Future work using dynamic systems modeling (Asparouhov, Hamaker, & Muthén, 2018; Hamaker, Asparouhov, Brose, Schmiedek, & Muthén, 2018; Oravecz & Brick, 2019; Ou, Hunter, & Chow, 2017) could help evaluate the timing of changes in felt love, what triggers these changes, how these changes affect other factors, and when interventions might be most needed and effective.

Because variability in felt love was found to be associated with self-reported sleep quality, additional studies are needed to assess the direct and indirect impacts of such feelings on other day-to-day experiences (e.g., interactions with family, friends, and coworkers) and symptoms of health and psychological conditions. This is especially important given work by Major et al. (2018), who revealed in a 7-day daily diary study that perceived positivity resonance was associated with mental health, loneliness, and symptoms of depression and illness, even after they controlled for daily positive emotions and social interaction. In this context, our findings demonstrate the importance of evaluating the relationships between felt love and other well-being variables at different time scales over a longer period of time, which might reveal important patterns that could inform points of potential intervention. For example, interventions targeting work or school communities could encourage acts of kindness directed toward coworkers and peers. Interventions could also target individuals and guide them through self-compassion training, which has been shown to have an association with sleep quality (Kemper, Mo, & Rami Khayat, 2015). We therefore recommend a new line of studies that empirically investigate felt love in everyday life and how it predicts well-being outcomes.

One limitation to this study is the measure of sleep quality; particularly, self-report ratings of sleep quality do not always align with objective measures of sleep quality (Armitage, Trivedi, Hoffmann, & Rush, 1997; Baker, Maloney, & Driver, 1999). If this is the case, felt love might not directly influence objective sleep quality but might only be related to reporting of sleep quality. However, some studies suggest that subjective measures of sleep quality capture certain features that objective measures do not—namely feel-

ings of being tired or sleepy versus feelings of being well-rested or energetic—and these features may be more relevant in assessing other subjective experiences. Future studies should attempt to replicate the findings from the present study by comparing objective measures such as polysomnography or actigraphy with subjective ratings in order to assess this possibility (as suggested also in Dewald et al., 2010). This information should become increasingly plausible to incorporate into research on daily experiences as wearable devices become available and are validated against traditional objective measures.

It is also important to note that most of the participants ($n = 46$) in the present study reported being in a romantic relationship, leaving only a few who reported being single ($n = 6$); thus, differences in effects between those in a relationship and those who were single were not tested. As a result, no conclusions can be drawn as to whether there is a difference in sleep quality or felt love between these two groups, and these results may not accurately represent the relationship between felt love and sleep quality in those who are single. Sharing a bed with another person has been found to have a negative relationship with sleep quality in women and a positive relationship with sleep quality in men, and sexual contact may have even greater implications (Dittami et al., 2007). Future studies should assess the potential differences in benefits drawn from felt love between people who are and are not in romantic relationships and should take sleeping arrangement and other factors such as relationship satisfaction into consideration.

Additionally, although felt love is defined to be an experience entirely within a single person, it is often experienced in contexts that involve others. This study did not differentiate between monadic, dyadic, and group contexts for feelings of love. Although this is not a methodological limitation and does not affect the interpretation or validity of our results, it would be valuable to assess potential differences between monadic felt love and felt love in dyadic or group contexts (e.g., Boker & Laurenceau, 2006). Our cultural consensus theory analysis revealed that felt love can stem from a number of different sources and contexts. Future research may consider studying how prevalent these different sources are in daily life, although Fredrickson (2016, p. 849) suggested that variation in the experience of love “may be largely a matter of degree, rather than kind.”

Finally, the design of the present study also does not allow causal inference. It is possible that the direction of causality is reversed, such that people who sleep better at night are more sensitive to acts of love in their lives. This possibility is supported by prior findings that there are bidirectional associations between affect and sleep quality (Kalmbach, Pillai, Roth, & Drake, 2014; van Zundert, van Roekel, Engels, & Scholte, 2015), although much of the existing literature focuses on unidirectional analyses. We thus encourage future researchers to pursue bidirectional models to examine this possibility with felt love and sleep quality.

Conclusions

This 4-week longitudinal EMA study explores the connection between daily felt love and sleep quality. This study replicated results from prior studies by

establishing a cultural consensus on what constitutes felt love and furthers these studies by discussing example situations that participants agree would make someone feel loved. After establishing this consensus, results relating to our main hypotheses suggest that although overall mean levels of felt love do not influence sleep quality, it is valuable to experience felt love in a range of intensities: Those who experienced greater average within-day variability in felt love across the month reported sleeping better on average than those who experienced less within-day variability in felt love. This finding that average within-day variability was a significant predictor of sleep quality, not mean levels or between-day variability, also highlights the importance of studying variability at multiple time scales so that we may better understand the systems at play.

APPENDIX. ECM CONSENSUS RESULTS

Item no.	Most people feel loved when . . .	True/false mean	Consensus label	Item difficulty	Item difficulty rank
1	Someone supports them without expecting anything in return	1.00	True	-1.36	47
2	They feel accepted	1.00	True	-1.64	49
3	They make up after a fight	1.00	True	0.11	28
4	They are hugged	1.00	True	-1.71	55
5	Somebody confides in them	1.00	True	1.19	16
6	They feel connected to god	1.00	True	-0.13	32
7	They play sports	0.00	False	0.24	26
8	The sun is shining	0.00	False	1.48	13
9	Someone tells them what is best for them	0.00	False	0.99	17
10	Someone is there just to listen	1.00	True	-1.69	54
11	They feel appreciated	1.00	True	-1.68	53
12	They feel part of a team	1.00	True	-0.02	29
13	Someone understands them	1.00	True	-0.10	30
14	Someone is sexually attracted to them	0.99	True	1.78	12
15	They receive gifts (cards, flowers, etc.)	1.00	True	-1.68	52
16	They spend time with their child(ren)	1.00	True	-1.16	43
17	Someone helps them out	1.00	True	-0.33	34
18	Someone follows up to ask how a problem turned out	1.00	True	0.52	24
19	Someone gives them positive feedback on the internet (e.g., a Facebook like, a retweet)	0.92	True	2.67	4
20	They get a compliment from a stranger	0.22	False	2.95	3
21	They make love	1.00	True	-1.67	51

Item no.	Most people feel loved when . . .	True/false mean	Consensus label	Item difficulty	Item difficulty rank
22	Someone cares for them when they are sick	1.00	True	-3.36	60
23	Someone forgives them for something they did wrong	1.00	True	0.61	23
24	Their pets are happy to see them	1.00	True	-2.62	58
25	They attend a religious ceremony	0.99	True	2.30	8
26	They attend sporting events of their favorite team	0.00	False	1.20	15
27	They solve a difficult problem	0.00	False	0.78	21
28	Someone else wants to know where they are at all times	0.00	False	0.91	19
29	They are made to feel special	1.00	True	-3.34	59
30	They spend time with their family (e.g., holidays, vacation)	1.00	True	-1.37	48
31	Someone can immediately tell what is on their mind	0.83	True	3.17	1
32	Someone does something nice for them unexpectedly	1.00	True	-0.92	40
33	Someone is supportive of their life goals	1.00	True	-1.04	42
34	A child snuggles up to them	1.00	True	-0.96	41
35	They are included in activities	1.00	True	-0.38	35
36	They receive a compliment	1.00	True	0.64	22
37	Someone insists to spend all of their time with them	0.00	False	1.87	11
38	Someone tells them: "I love you"	1.00	True	-1.79	57
39	Someone calls just to check in on them	1.00	True	-1.18	45
40	They are around people, having fun	1.00	True	1.29	14
41	Someone shows compassion towards them in difficult times	1.00	True	-0.85	39
42	Someone celebrates their accomplishments	1.00	True	-1.66	50
43	They spend quality time with someone	1.00	True	-1.35	46
44	They feel completely comfortable around someone	1.00	True	-0.61	36
45	They hear or sing their country's national anthem	0.00	False	2.02	10
46	They eat their favorite food	0.01	False	2.34	7
47	Someone is possessive about them	0.00	False	0.98	18
48	Someone is polite to them	0.01	False	2.51	5
49	They can share their opinions without being judged	1.00	True	0.37	25
50	They are holding hands	1.00	True	-1.16	44
51	They experience an act of kindness	1.00	True	-0.13	31
52	They have fun with their friends	1.00	True	-0.29	33
53	When someone sends them signs of affection (e.g., slight smile, loving glance)	1.00	True	-0.66	37
54	They feel close to nature	0.01	False	2.50	6
55	A group recognizes their contribution	1.00	True	0.90	20
56	Something nice happens to them unexpectedly	0.76	True	3.17	2
57	Someone tries to change their behavior to be healthier	0.00	False	2.17	9
58	They are recipients of gratitude	1.00	True	-0.75	38
59	Someone kisses them	1.00	True	-1.71	56
60	They feel someone has no expectations and they can be themselves	1.00	True	0.12	27

Note. Item numbers refer to the order in which the items were presented on the questionnaire. Item difficulty and true/false mean are rounded to 2 decimal points. Item difficulty ranks are established before rounding of item difficulty. Negative item difficulties indicate items that were much easier to answer, and positive items indicate items that were more difficult to answer.

NOTES

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1. The model was fitted with 3,000 iterations, 1,000 burn-in observations, and two chains. Ability, guessing bias, and willingness to guess were allowed to vary across participants. Gender and relationship status were included as covariates on the ability parameter. Item difficulty was allowed to vary across items. Model setup file and model output are available at https://osf.io/5c3xp/?view_only=87288813b1464801a6ba74fe5278c835.

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