THE GERONTOLOGICAL SOCIETY OF AMERICA®

Journals of Gerontology: Psychological Sciences
cite as: *J Gerontol B Psychol Sci Soc Sci*, 2019, Vol. 74, No. 6, 975–987
doi:10.1093/geronb/gbx157
Advance Access publication January 27, 2018

OXFORD

Original Research Report

Genuine Smiles by Patients During Marital Interactions are Associated with Better Caregiver Mental Health

Sandy J. Lwi, PhD,[1] James J. Casey, PhD,[1] Alice Verstaen, MA,[1] Dyan E. Connelly, MA,[1] Jennifer Merrilees, RN, PhD,[2] and Robert W. Levenson, PhD[1]

[1]Department of Psychology, University of California, Berkeley. [2]Department of Neurology, University of California, San Francisco.

Address correspondence to Robert W. Levenson, PhD, Department of Psychology, University of California, Berkeley, CA 94720. E-mail: boblev@berkeley.edu.

Received: May 15, 2017; Editorial Decision Date: November 8, 2017

Decision Editor: Bob G. Knight, PhD

Abstract

Objective: Providing care for a spouse with dementia is associated with an increased risk for poor mental health. To determine whether this vulnerability in caregivers is related to the expression of positive emotion, we examined 57 patients with Alzheimer's disease and behavioral variant frontotemporal dementia and their spouses as they discussed a marital conflict.
Method: Facial behavior during the discussion was objectively coded to identify Duchenne (i.e., genuine) smiles and non-Duchenne (i.e., polite) smiles. Caregiver mental health was measured using the Medical Outcomes Survey.
Results: Greater expression of Duchenne smiles by patients was associated with better caregiver mental health, even when accounting for covariates (i.e., diagnosis, patient cognitive functioning, and caregiver marital satisfaction). Greater expression of non-Duchenne smiles by patients was associated with worse caregiver health, but only when covariates were entered in the model. Expression of Duchenne and non-Duchenne smiles by caregivers was not associated with caregiver mental health.
Discussion: Patients' expression of Duchenne and non-Duchenne smiles may reveal important aspects of the emotional quality of the patient–caregiver relationship that influence caregiver burden and mental health.

Keywords: Caregiving, Dementia, Mental health, Positive emotion, Smiling.

Familial caregivers of patients with dementia are faced with the enormous challenge of caring for a loved one whose level of functioning progressively deteriorates. As a group, dementia caregivers are more prone to mental health problems than non-caregiving older adults (Schulz & Eden, 2016). However, individual caregivers differ greatly in the extent to which they experience these negative outcomes. Prior research indicates that behavioral and psychological symptoms in patients can be particularly difficult for caregivers, even more so than cognitive and functional symptoms (Schulz, O'Brien, Bookwala, & Fleissner, 1995). These behavioral symptoms in patients can be particularly challenging when manifest in interactions with caregivers (Ascher et al., 2010). In the present study, we focused on an important aspect of patient behavior, the expression of positive emotion that occurs during patient–caregiver interactions, and its association with caregivers' mental health.

Patient Emotional Behavior, Patient–Caregiver Relationship Quality, and Caregiver Mental Health

Patients with Alzheimer's disease (AD) and behavioral variant frontotemporal dementia (bvFTD) undergo a number of changes in emotional behavior that can have a negative impact on caregivers. For example, as AD patients' dementia progresses, problematic behaviors such as anger

and aggression become increasingly difficult to manage, leading to worse mental health in caregivers (Schulz & Sherwood, 2008). Similarly, as bvFTD progresses, patients undergo dramatic changes in personality and express greater levels of apathy and social inappropriateness, which leads to greater levels of burden, depression, and distress in caregivers (Merrilees et al., 2013).

Despite the established links between patient behavioral symptoms and worse caregiver mental health, studies of caregiver health that have focused on qualities of the patient–caregiver relationship have been rare. This is unfortunate, because spouses and relationship partners often are called on to serve as primary caregivers for patients with dementia (Schulz & Eden, 2016), and dementia can profoundly affect these relationships. For example, patients with bvFTD may become more emotionally blunted and less empathic (Rascovsky et al., 2011), leading to a weakening of the emotional connection with their partner. In previous studies of dyadic interactions, patients with FTD and their spousal caregivers showed less mutual gaze during conversations about a relationship problem and reported lower marital satisfaction than healthy controls (Sturm et al., 2011). Alzheimer's disease can also affect relationships. For example, a longitudinal study found that caregivers' social intimacy with the patient declined over time (Blieszner & Shifflett, 1990). Loss of closeness between the patient and caregiver can be devastating, especially in later life when social networks shrink and close relationships become increasingly more important (Cornwell, Laumann, & Schumm, 2008). Thus, not surprisingly, poor relationship quality has been strongly associated with worse caregiver mental health (Mahoney, Regan, Katona, & Livingston, 2005).

Positive Emotional Behavior and Intimate Relationships

Positive emotional behaviors are particularly important indicators of the state of intimate relationships. Consistent with this, a primary function of positive emotions is to broaden and build social relationships (Fredrickson, 2004). Experiencing positive emotions has been linked to stronger social bonds and social connection (Losada & Heaphy, 2004), and encourages individuals to explore and engage in new experiences, which increase social integration (Fredrickson, 2004). For example, when mothers look at photographs of their infants smiling, dopaminergic reward-related brain areas show greater activation than when infants' neutral or sad expressions are viewed; this reinforcement associated with smiles may play an important role in building mother–infant attachments (Strathearn, Li, Fonagy, & Montague, 2008). Positive emotions are also important in romantic relationships; people who express greater happiness in college yearbook photographs report higher levels of marital satisfaction 30 years later (Harker & Keltner, 2001). Greater expressions of love and other positive emotions during a conflict are associated with higher levels of relationship satisfaction and a greater likelihood of engaging in constructive behaviors (e.g., affirmation, soothing contact, expressing concern; Gonzaga, Keltner, Londahl, & Smith, 2001).

Positive Emotional Behavior and Health

In the literature on emotion and health, individuals who experience greater positive emotions also experience better health outcomes (e.g., Wichers et al., 2007). Positive emotions are thought to help build personal resources (Fredrickson, 2004) which, in turn, have been associated with individuals' ability to utilize coping strategies and be resilient (Fredrickson, Tugade, Waugh, & Larkin, 2003), both of which are important for mental health. Although rarely examined, the link between positive emotion and health is also found in close relationships. For example, individuals with happier spouses report better health, fewer physical impairments, and less chronic disease (Chopik & O'Brien, 2016). Exhibiting and eliciting positive emotions fosters supportive environments that promote coping (Fredrickson, 2004), and smiling has been found to be particularly effective for eliciting greater cooperation from others (Johnston, Miles, & Macrae, 2010). In the realm of caregiving where one spouse has dementia, patients' positive communication behaviors (e.g., humor) have been linked to lower depression in the caregiving spouse (Braun, Mura, Peter-Wight, Hornung, & Scholz, 2010).

Measuring Positive Emotion

Emotions can be measured via self-reported subjective experience, expressive behavior, and peripheral and central nervous system physiology (Levenson et al., 2017). Emotional facial expressions, with their high signal value for conspecifics, may be particularly important indicators of the emotional life of couples (Levenson, Haase, Bloch, Holley, & Seider, 2013). Although there are a number of different positive emotions (e.g., pride, amusement, contentment), most positive emotions share the smile as a common expressive element (Campos, Shiota, Keltner, Gonzaga, & Goetz, 2013). Moreover, particular morphological features of the smile are thought to convey whether the emotion is genuinely felt (i.e., "Duchenne smiles," which involve the raising of the lip corners and the raising of the cheeks) or not genuinely felt ("non-Duchenne" or "polite" smiles, which only involve the raising of lip corners; Ekman & Friesen, 1982). In dementia research, assessing emotion via facial expressions has the additional advantage of reducing the problems associated with retrospective self-reports of emotion in patients who may have deficits in language, memory, and self-awareness. Despite these advantages, we are aware of no prior studies of the associations between patients' emotional behaviors and

caregivers' mental health that have utilized objective coding of emotional facial expressions during patient–caregiver interactions.

The Present Study

We studied positive emotional facial expressions (Duchenne and non-Duchenne smiles) that occurred during the first 30 s of a 10-min discussion of an area of marital conflict in a sample of patients with dementia and their spousal caregivers. Expressions were coded using the Facial Action Coding System (FACS, Ekman & Friesen, 1977), a precise anatomically based system that can decompose observable facial behavior in terms of its underlying muscular contractions. The first 30 s of the interaction were chosen because they capture a period of reconnection after couples had sat for 5 min of enforced silence. In healthy couples, these "reunion" periods are highly diagnostic of the quality of the relationship. For example, after a similar period of enforced silence, greater positive emotion expressed during the first 3 min of a discussion of an area of marital conflict predicted lower likelihood of divorce (Carrère & Gottman, 1999). Focusing on only 30 s of facial behavior has practical advantages as well. FACS coding is highly time-consuming; when applied thoroughly, it typically takes 100 min to code 1 min of behavior, and it is a slow process even when only coding for Duchenne and non-Duchenne smiles. Moreover, studying "thin slices" of behavior (typically ranging from 10 to 30 s) is a well-established procedure for capturing important qualities of individuals and dyads (Ambady, Bernieri, & Richeson, 2000).

Because different forms of dementia affect different brain regions and have different effects on emotional functioning (Seeley et al., 2007), we included patients with two common forms of dementia: AD—a dementia that affects the temporal and parietal lobes and primarily impairs memory and cognition, and bvFTD—a dementia that affects the frontal and temporal lobes and primarily produces changes in emotion, personality, and behavior. Among the various subtypes of frontotemporal dementia, we focused on bvFTD because language problems associated with other subtypes (i.e., semantic variant primary progressive aphasia, non-fluent variant primary progressive aphasia) could interfere with patients' ability to engage in the conflict conversation.

Our primary hypothesis was that more Duchenne smiles (thought to indicate genuine positive emotion; Ekman & Friesen, 1982) expressed by patients and their spousal caregivers would be associated with better caregiver mental health. We did not expect this relationship to be found for non-Duchenne smiles.

Method

Participants

Twenty-nine patients with AD and 28 patients with bvFTD and their spousal caregivers were recruited through the Memory and Aging Center at the University of California, San Francisco. Patients were evaluated by a multidisciplinary team and diagnosed based on neurological, neuropsychological, and neuroimaging data using consensus criteria for AD (McKhann et al., 1984) and FTD (Rascovsky et al., 2011). Patients were generally in the early stage of their disease (see Mini-Mental State Examination [MMSE] scores in Table 1) and thus were able to understand and follow task instructions (as confirmed by verbal checks with session facilitators). Both patients and caregivers needed to be sufficiently healthy to travel to the University of California, Berkeley to complete the day-long laboratory session. Patients who met criteria for Mild Cognitive Impairment (i.e., patients with cognitive impairments that were not significant enough to interfere with daily activities) were excluded. Table 1 presents demographic characteristics for patients and caregivers. All couples were paid $30 in addition to any transportation costs they incurred.

Procedure

A week before their laboratory visit, caregivers completed a questionnaire packet including measures of mental health and marital satisfaction. Patients and caregivers then came to the Berkeley Psychophysiology Laboratory for a day-long comprehensive assessment of emotional and social functioning. Upon arrival, participants were informed that their physiological, behavioral, and self-reported responses would be recorded and videotaped. Prior to the start of the laboratory session, participants had sensors attached for monitoring autonomic and somatic physiological responses (these data were not used for the present study). Throughout the session, participants' upper body and face were filmed using a partially concealed video camera.

The present study focused on a laboratory task in which couples sat quietly during a 5-min baseline period and then had an unrehearsed discussion about an area of marital conflict (i.e., conflict conversation) for 10 min. This procedure was originally developed for studying marital interactions in healthy couples (Levenson & Gottman, 1983), but has also been used with dementia patients and their caregivers (Ascher et al., 2010; Sturm et al., 2011). The discussion occurred for each couple immediately after an hour-long break for lunch; anecdotally, many couples reported having good energy levels at this point in the day.

Measures

Positive emotional expressions

Using the Facial Action Coding System (FACS; Ekman & Friesen, 1977), trained coders blind to diagnosis and caregiver outcomes measured smiling behaviors expressed by both spouses during the first 30 s of the 10-min conflict conversation.

Table 1. Sociodemographic Characteristics of Patients with Behavioral Variant Frontotemporal Dementia, Alzheimer's Disease, and Patients' Spousal Caregivers

	Patients with AD	Spousal caregivers of patients with AD	Patients with bvFTD	Spousal caregivers of patients with bvFTD
n	29	29	28	28
Age (*M* [*SD*])	61.92 (8.89)	61.08 (8.77)	61.78 (8.22)	60.21 (8.04)
Sex	15 M, 14 F	13 M, 16 F	20 M, 8 F	9 M, 19 F
Smiles				
Duchenne				
Frequency	1.03 (1.30)	0.97 (1.13)	0.97 (1.11)	1.04 (1.05)
Intensity	1.39 (1.67)	1.51 (1.70)	0.98 (1.45)	1.01 (1.44)
Duration	4.72 (5.93)	3.97 (5.41)	4.69 (6.41)	3.74 (4.60)
Composite	0.04 (0.99)	0.03 (0.93)	−0.05 (0.90)	−0.03 (0.91)
Non-Duchenne				
Frequency	1.26 (1.48)	1.19 (1.29)	0.88 (1.17)	1.19 (1.15)
Intensity	1.16 (1.14)	1.43 (1.41)	0.99 (1.04)	1.35 (1.05)
Duration	3.88 (4.63)	5.52 (7.58)	3.04 (4.17)	4.79 (5.97)
Composite	0.08 (1.03)	−0.02 (0.99)	−0.08 (0.89)	0.02 (0.88)
Marital satisfaction	—	111.65 (30.71)	—	96.40 (28.25)
MMSE (*M* [*SD*])	21.97 (5.12)	—	25.07 (4.12)	—
Mental Health (*M* [*SD*])	—	0.35 (0.91)	—	−0.36 (1.12)

Note. For smiles, three raw subscores are presented: frequency (number of Duchenne smiles), intensity (average intensity of the Duchenne smile), and duration (number of seconds during the film during which there is a Duchenne smile). Logarithmic transformations were applied to the subscores to reduce skewness. Subscores were then normalized (using the means and standard deviations for the entire sample) and averaged to derive the score for the two kinds of smiles (see Keltner & Bonanno, 1997). Higher scores on marital satisfaction indicate greater satisfaction (range: 2–158); lower scores on MMSE indicate lower cognitive functioning (range: 0–30). A dash (—) indicates that the given variable was not measured.
AD = Alzheimer's disease; bvFTD = behavioral variant frontotemporal dementia; MMSE = Mini-Mental State Exam.

To develop reliability, all coders completed practice coding assignments of older adults' emotional behavior and met weekly to discuss discrepancies before coding the reliability sample of 18 dyads (30% of the sample). High reliability was required for the practice coding assignments (Cronbach's $\alpha > 0.70$) before coders completed their work for the remaining dyads.

In order to ensure that individual differences in facial features (e.g., elasticity) were taken into account when coding, all coders were provided with neutral stills of each patient and caregiver, and instructed to only code facial expressions that clearly resulted from changes in specific facial muscle movements. FACS is a well-validated and widely used measure (Ekman & Rosenberg, 2005), and has been successfully utilized in prior studies examining facial expressions in older adults and adults with neurodegenerative diseases (Lints-Martindale, Hadjistavropoulos, Barber, & Gibson, 2007).

Based on prior research (Ekman & Friesen, 1982), smiles were classified as genuine Duchenne smiles if they included contraction of both the orbicularis oculi (cheek raise, action unit [AU]6 and/or AU7) and zygomatic major (lip corner raise, AU12) or as "polite" non-Duchenne smiles if they consisted only of the contraction of the zygomatic major (AU12). Duchenne and non-Duchenne smiles with an opened mouth (AU25 or AU26) were also included. Smiles that are accompanied by AUs associated with negative emotions generally are not deemed to be signs of genuine positive emotion. Thus, smiles accompanied by action units typically associated with negative emotions (e.g., disgust, sadness, anger) such as AU9 (nose wrinkling), AU15 (frowning), or AU4 (brow furrowing) were not included in the analyses. These exclusionary criteria have been used in previous studies of Duchenne smiles (Haase et al., 2015).

For each participant, one score was derived to characterize Duchenne smiling and a second score was derived to characterize non-Duchenne smiling. To produce these scores, we first computed three subscores for each kind of smile: (a) the number of smiles that occurred during the conversation; (b) the average intensity of all smiles at their apex or most intense level of facial action (based on 1–5 intensity of AU12), and (c) the average duration of all smiles. Our measures of Duchenne and non-Duchenne smiles were moderately skewed (skew ≥1). In order to reduce skewness, a constant of one was added to each subscore (i.e., frequency, duration, intensity) before logarithmic transformations were applied. This reduced the skew of each variable to ≤1, providing a more normal distribution for analyses. Subscores were then normalized (using the means and standard deviations for the entire sample) and averaged to derive the score for the two kinds of smiles (see Keltner & Bonanno, 1997). To determine inter-rater reliability, two FACS-certified coders and two

trained FACS coders scored 18 conversations. Inter-rater reliability for the Duchenne and non-Duchenne scores was high (Cronbach's $\alpha = 0.84$).

Caregiver mental health

Caregiver mental health was assessed using the Medical Outcomes Study (MOS SF-36; Tarlov et al., 1989). The MOS SF-36 is a 36-item self-report measure designed to assess eight health domains: (a) physical functioning, (b) role limitations due to physical health, (c) energy/fatigue, (d) pain, (e) general health problems, (f) role limitations due to emotional problems, (g) emotional well-being, and (h) social functioning. Scores for each of these domains ranged from 0 (worst) to 100 (best). According to convention (Ware, 2000), all subscales were z-scored and weighted to create a composite score of mental health such that mental health subscales are weighted more heavily than other subscales; this weighting reduces but does not eliminate the influence of physical health on caregivers' mental health scores. This scoring scheme has been used extensively in the literature (Bourke-Taylor, Pallant, Law, & Howie, 2012; Hawthorne, Osborne, Taylor, & Sansoni, 2007) and its reliability and validity for predicting mental health is well-established (McHorney, Ware, & Raczek, 1993).

Marital satisfaction

Caregivers completed the Locke–Wallace Marital Adjustment Test (Locke & Wallace, 1959), a well-validated 15-item scale (e.g., "To what extent do you and your mate agree or disagree on handling family finances" [0 = Always disagree, 5 = Always agree]) that we have used in prior research with dementia patients and caregivers (Ascher et al., 2010). Scores can range between 2 and 158, with higher scores indicating greater marital satisfaction.

Cognitive functioning

Patients' cognitive functioning was assessed using the MMSE (Folstein, Folstein, & McHugh, 1975), a well-validated 30-item test that measures memory, orientation, attention, and language. Items were summed, with higher scores indicating higher cognitive functioning. When interpreting scores, sums between 25 and 30 indicate questionable cognitive impairment, 20–25 indicate mild cognitive impairment, 10–20 indicate moderate cognitive impairment, and 0–10 indicate severe cognitive impairment.

Results

Data Analysis

Preliminary analyses were conducted to examine whether patients with bvFTD and AD differed in age, sex, cognitive functioning, Duchenne smiles, and non-Duchenne smiles. Similar analyses were conducted to examine whether caregivers differed in age, sex, marital satisfaction, Duchenne smiles, and non-Duchenne smiles.

For our primary hypothesis that Duchenne smiles by patients and caregivers would be associated with better caregiver mental health, we conducted a linear regression analysis in which the four kinds of smiles (patient and caregiver Duchenne and non-Duchenne) were entered together on the same step as predictors and caregiver mental health was the dependent variable. This analysis was then re-run with diagnosis included as a covariate, reflecting prior findings that indicate that symptoms associated with bvFTD and AD create different kinds of burdens and challenges for caregivers (Nunnemann, Kurz, Leucht, & Diehl-Schmid, 2012). When associations were found between a particular kind of smile and caregiver mental health, we conducted regression analyses that included the interaction of that kind of smile with diagnosis. Finally, to evaluate the robustness of our findings, we repeated the main regression analysis while accounting for variables that differed across diagnostic groups (i.e., marital satisfaction, cognitive functioning; see Preliminary Analyses). This analysis revealed a potential suppressor effect, thus, additional post hoc analyses were conducted to understand this effect. An additional exploratory analysis was conducted to examine whether marital satisfaction mediated the relationship found between patient Duchenne smiles and caregiver mental health.

Preliminary Analyses

Age and sex differences

Group differences in AD and bvFTD patients' age were analyzed using an independent *t*-test; sex differences were analyzed using a Chi-square test. Results revealed no patient differences in age, $t(55) = 0.07$, $p = .948$ or sex, χ^2 (1, N=57) = 2.33, $p = .127$. Parallel analyses were conducted to examine group differences for caregivers. Results revealed no caregiver differences in age, $t(55) = 0.39$, $p = .699$ or sex, χ^2 (1, N = 57) = 0.97, $p = .325$.

Duchenne and non-duchenne smiles

Group differences in bvFTD and AD Duchenne and non-Duchenne smiles were examined using independent *t*-tests. No group differences were found in patient Duchenne $t(55) = 0.36$, $p = .721$ and non-Duchenne smiles $t(55) = 0.63$, $p = .530$, or in caregiver Duchenne $t(55) = 0.24$, $p = .809$ and non-Duchenne smiles $t(55) = -0.15$, $p = .881$.

To examine correlations between patient and caregiver Duchenne smiles, Pearson's r and Spearman's rho were both used. Spearman's rho was included because behavioral data often shows non-normal distributions, and thus may benefit from a non-parametric analysis. Results indicated a significant association between patient and caregiver Duchenne smiles ($r = 0.38$, $p = .004$; $r_s = 0.38$, $p = .003$), but no significant association between patient

and caregiver non-Duchenne smiles (r = 0.21, p = .120; r_s = .20, p = .131.[1]

Marital satisfaction

Group differences in caregivers' self-reported marital satisfaction were analyzed using an independent t-test. Differences in caregiver marital satisfaction approached significance across groups, $t(55)$ = 1.95, p = .056, with caregivers of patients with bvFTD reporting lower marital satisfaction scores (M = 96.40, SD = 28.25) than caregivers of patients with AD (M = 111.65, SD = 30.71). Although group differences only approached significance, caregiver marital satisfaction was entered as a covariate in our analyses given prior findings of links between marital satisfaction and caregiver mental health (Kouros, Papp, & Cummings, 2008).

Cognitive functioning

Group differences in AD and bvFTD patients' Mini-Mental State Exam (MMSE) scores were analyzed using an independent t-test. Patient groups differed significantly in MMSE, $t(55)$ = –2.52, p = .015, with patients with bvFTD having higher scores (M = 25.07, SD = 4.12) than patients with AD (M = 21.97, SD = 5.12). Consequently, patient MMSE scores were entered as a covariate in our analyses.

Duchenne smiles and caregiver mental health

As depicted in Table 2 (model 1), the regression analysis revealed that patient Duchenne smiles were significantly associated with caregiver mental health, B = 0.39, $SE(B)$ = 0.17, β = 0.34, p = .029, CI = [0.05, 0.73] whereas caregiver Duchenne smiles were not, B = –0.08, $SE(B)$ = 0.18, β = –0.07, p = .669, CI = [–0.43, 0.28]. When this analysis was repeated with diagnosis included as a covariate (see Table 2, model 2), these results remained significant for patient Duchenne smiles (B = 0.37, $SE(B)$ = 0.16, β = 0.32, p = .025, CI = [0.05, 0.69]) while caregiver Duchenne smiles remained non-significant (B = –0.09, $SE(B)$ = 0.17, β = –0.07, p = .609, CI = [–0.42, 0.25]). Diagnosis was also significantly associated with caregiver mental health, B = –0.71, $SE(B)$ = 0.26, β = –0.34, p = .009, CI = [–1.24, –0.18]; caregivers of patients with AD reported having better mental health than caregivers of patients with bvFTD. Patient and caregiver non-Duchenne smiles were not associated with caregiver mental health (ps > 0.159). Model fit was significant ($R^2_{adjusted}$ = 0.144, $F(5, 51)$ = 2.89, p = .023).

Because we observed an association between patient Duchenne smiles and caregiver mental health, we determined whether this relationship varied by diagnosis by fitting another regression model that included the interaction of patient Duchenne smiles and diagnosis. As seen in Table 2 (model 3), analyses revealed that patient Duchenne smiles (B = 0.38, $SE(B)$ = 0.16, β = 0.33, p = .027, CI = [0.05, 0.70]) and patient diagnosis remained significantly associated with better caregiver mental health (B = –0.71, $SE(B)$ = 0.27, β = –0.34, p = .010, CI = [–1.25, –0.18]), but no association was found between the interaction term (patient Duchenne smiles × diagnosis) and caregiver mental health (B = –0.03, $SE(B)$ = 0.14, β = –0.03, p = .850, CI = [–0.31, 0.26]). The associations between patient non-Duchenne smiles and both caregiver smiles (Duchenne and non-Duchenne) and caregiver mental health also remained non-significant (ps > .166). Model fit remained significant ($R^2_{adjusted}$ = 0.128, $F(6, 50)$ = 2.37, p = .043).

To examine the robustness of our findings, we conducted the main analysis while also accounting for patient diagnosis and two additional variables that differed between diagnostic groups—cognitive functioning (i.e., MMSE) and caregiver marital satisfaction. As depicted in Table 2 (model 4), results indicated that patient Duchenne smiles remained significantly associated with better caregiver mental health (B = 0.42, $SE(B)$ = 0.15, β = 0.37, p = .008, CI = [0.12, 0.72]). In addition, patient non-Duchenne smiles became associated with worse caregiver mental health (B = –0.30, $SE(B)$ = 0.14, β = –0.27, p = .036, CI = [–0.57, –0.02]). Marital satisfaction was also significantly associated with caregiver mental health (B = 0.01, $SE(B)$ = 0.00, β = 0.38, p = .003, CI = [0.005, 0.022].[2,3] while diagnosis showed an

1. The moderate correlation between patient and caregiver Duchenne smiles suggests that patients who expressed more genuine smiles have caregivers who do the same. To examine whether patients and caregivers who expressed more genuine smiles may also report greater caregiver marital satisfaction and mental health, a median split was computed in order to group patients who expressed fewer Duchenne smiles and patients who expressed greater Duchenne smiles. Group differences in caregiver marital satisfaction and mental health were then examined using independent t-tests. Analyses revealed a non-significant difference in marital satisfaction $t(55)$ = 0.14, p = .892 and a difference that trended towards significance in caregiver mental health $t(55)$ = –1.94, p = .058, such that caregivers of patients who expressed more Duchenne smiles reported higher mental health scores (M = 0.27, SD = 0.77) than caregivers of patients who expressed fewer Duchenne smiles (M = –0.26, SD = 1.26).

2. Studies have also computed the MOS-SF 36 mental health composite scale by summing the following four subscales: vitality, social functioning, limitations due to emotional problems, and mental health (Zhu et al., 2016). When analyses were conducted using this alternative approach, results indicated that patient Duchenne smiles were associated with caregiver mental health at near significant levels B =25.65, $SE(B)$ = 13.06, β = 0.29, p = .055, CI = [–0.56, 51.86], but caregiver Duchenne smiles, and both patient and caregiver non-Duchenne smiles were not (ps > .203). When accounting for patient cognitive functioning and caregiver marital satisfaction, patient Duchenne smiles remained positively associated with better caregiver mental health (B = 29.57, $SE(B)$ = 12.22, β = 0.33, p = .019, CI = [5.01, 54.12]) while patient non-Duchenne smiles remained associated with worse caregiver mental health (B = 23.33, $SE(B)$ = 11.12, β = –0.27, p = .041, CI = [–45.67, –0.99]).

Table 2. Duchenne and non-Duchenne Smiles as Predictors of Caregiver Mental Health

	Caregiver mental health									
	Model 1		Model 2		Model 3		Model 4		Model 5	
	B (*SE*[*B*])	β	*B* (*SE*[*B*])	β	*B* (*SE*[*B*])	β	*B* (*SE*[*B*])	β	*B* (*SE*[*B*])	β
Patient Duchenne	0.39 (0.17)	0.34*	0.37 (0.16)	0.32*	0.38 (0.16)	0.33*	0.42 (0.15)	0.37**	0.37 (0.16)	0.33*
Caregiver Duchenne	−0.08 (0.18)	−0.07	−0.09 (0.17)	−0.07	−0.08 (0.17)	−0.07	−0.11 (0.16)	−0.09	−0.10 (0.17)	−0.09
Patient non-Duchenne	−0.17 (0.15)	−0.16	−0.21 (0.14)	−0.18	−0.20 (0.15)	−0.18	−0.30 (0.14)	−0.27*	−0.20 (0.15)	−0.18
Caregiver non-Duchenne	−0.12 (0.18)	−0.11	−0.09 (0.17)	−0.08	−0.10 (0.18)	−0.09	−0.12 (0.16)	−0.11	−0.09 (0.17)	−0.08
Diagnosis	—	—	−0.71 (0.26)	−0.34**	−0.71 (0.27)	−0.34**	−0.53 (0.27)	0.25	—	—
Patient Duchenne × diagnosis	—	—	—	—	−0.03 (0.14)	−0.03	—	—	—	—
Patient non-Duchenne × diagnosis	—	—	—	—	—	—	—	—	−0.05 (0.15)	−0.05
Cognitive functioning	—	—	—	—	—	—	0.004 (0.03)	0.02	—	—
Marital satisfaction	—	—	—	—	—	—	0.01 (0.00)	0.38**	—	—

Note. Covariates include patient diagnosis and cognitive functioning, and caregiver marital satisfaction. Diagnosis was dummy-coded; patients with AD were set as the reference group. A dash (—) indicates that the given variable was not included within the model.
*$p < .05$, **$p < .01$.

association that trended towards significance ($B = -0.53$, $SE(B) = 0.27$, $\beta = -0.25$, $p = .052$, CI = [−1.06, 0.004]). Cognitive functioning was not associated with caregiver mental health ($B = 0.004$, $SE(B) = 0.03$, $\beta = 0.02$, $p = .871$, CI = [−0.05, 0.06]). The associations between caregiver Duchenne and non-Duchenne smiles and caregiver mental health remained non-significant ($ps > .439$). Model fit remained significant ($R^2_{adjusted} = 0.255$, $F(7, 49) = 3.74$, $p = .003$).

Because we observed an association between patient non-Duchenne smiles and caregiver mental health, we determined whether this relationship varied by diagnosis by fitting another regression model that included the four predictor variables (patient and caregiver Duchenne and non-Duchenne smiles) included both patient and caregiver Duchenne and non-Duchenne smiles). Patient Duchenne smiles remained significantly associated with caregiver mental health, $B = 0.39$, $SE(B) = 0.17$, $\beta = 0.34$, $p = .028$, CI = [0.04, 0.73] while caregiver Duchenne smiles remained non-significant, $B = 0.05$, $SE(B) = 0.20$, $\beta = 0.04$, $p = .813$, CI = [−0.36, 0.45]. Patient and caregiver non-Duchenne smiles likewise remained non-significant ($ps > .299$). When analyses included length of union as an additional covariate in Model 4 (where predictors included both patient and caregiver Duchenne and non-Duchenne smiles, as well as the covariates of patient diagnosis and cognitive functioning, and caregiver marital satisfaction), patient Duchenne smiles remained significantly associated with caregiver mental health, $B = 0.43$, $SE(B) = 0.16$, $\beta = 0.37$, $p = .009$, CI = [0.11, 0.74] while caregiver Duchenne smiles remained non-significant, $B = -0.01$, $SE(B) = 0.18$, $\beta = -0.01$, $p = .974$, CI = [−0.38, 0.36]. Patient diagnosis B = −0.62, $SE(B) = 0.28$, $\beta = -0.29$, p = .030, CI = [−1.18, −0.06] and caregiver marital satisfaction B = 0.01, $SE(B) = 0.01$, $\beta = 0.34$, $p = .013$, CI = [0.003, 0.02] remained significantly associated with caregiver mental health, while patient and caregiver non-Duchenne smiles and patient cognitive functioning remained non-significant ($ps > .072$).

The associations between caregiver Duchenne and non-Duchenne smiles and caregiver mental health remained non-significant ($ps > .628$).

3. Same-sex spouses may reveal unique differences due to gender, as women tend to smile more than men (LaFrance, Hecht, & Paluck, 2003), or additional stressors due to societal stigma (Lewis, Derlega, Griffin, & Krowinski, 2003). To examine whether same-sex couples impacted our findings, we re-ran analyses without these two couples. Results remained significant; patient Duchenne smiles remained significantly associated with caregiver mental health, $B = 0.38$, $SE(B) = 0.16$, $\beta = 0.33$, $p = .023$, CI = [0.05, 0.71] while caregiver Duchenne smiles were not, $B = -0.11$, $SE(B) = 0.17$, $\beta = -0.10$, $p = .512$, CI = [−0.46, 0.23]. The relationship between patient non-Duchenne smiles and caregiver non-Duchenne smiles and caregiver mental health remained non-significant ($ps > .096$) Results may also be affected by the length of time spouses have been married, as shorter times indicate newer spouses or second marriages, which have been found to affect marital quality and satisfaction (Bograd & Spilka, 1996; Coleman, Ganong, & Fine, 2000). To examine whether length of union impacted our findings, results were examined with length of union included as a covariate in Model 1 (where predictors

and the interaction of patient non-Duchenne smiles and diagnosis. As seen in Table 2 (model 5), the analysis revealed a non-significant interaction term (B = –0.04, $SE(B)$ = 0.15, β = –0.05, p = .746, CI = [–0.35, 0.25]), which remained non-significant when the analysis was repeated with additional covariates included (i.e., diagnosis, martial satisfaction, and cognitive functioning; B = –0.01, $SE(B)$ = 0.14, β = –0.01, p = .945, CI = [–0.28, 0.26]).

To further understand the potential suppressor effect in the association between patient non-Duchenne smiles and caregiver mental health, two additional post hoc regressions were conducted. In the first, the four kinds of smiles (patient and caregiver Duchenne and non-Duchenne) and patient cognitive functioning were entered as predictors, and caregiver mental health was the dependent variable. Patient non-Duchenne smiles were not significantly associated with caregiver mental health in this regression (B = –0.19, $SE(B)$ = 0.15, β = –0.17, p = .225, CI = [–0.49, 0.12]). In the second, the four kinds of smiles (patient and caregiver Duchenne and non-Duchenne) and marital satisfaction were entered as predictors, and caregiver mental health was the dependent variable. In this regression, patient non-Duchenne smiles were significantly associated with caregiver mental health (B = –0.29, $SE(B)$ = 0.14, β = –0.26, p = .042, CI = [–0.57, –0.01]), indicating that marital satisfaction may be acting as a suppressor variable. To further examine this effect, a median split was computed in order to group patients who expressed fewer non-Duchenne smiles and patients who expressed greater non-Duchenne smiles. Further analyses revealed marital satisfaction to be significantly associated with caregiver mental health (r = 0.55, p = .002) for patients who expressed more non-Duchenne smiles; this association was not significant for patients who expressed fewer non-Duchenne smiles (r = 0.33, p = .10).

Finally, having established an association between patient Duchenne smiles and caregiver mental health, we conducted an exploratory mediation analysis to test whether this association was mediated by marital satisfaction. Using the PROCESS macro (Hayes, 2008) with 50,000 bias-corrected bootstrapped samples, results revealed a non-significant mediation, B = –0.008, SE = (0.065), CI_{95} = [–0.15, 0.12].

Discussion

We examined whether smiles expressed by patients with bvFTD and AD and their spousal caregivers during an unrehearsed, semi-naturalistic conversation about a relationship conflict were associated with caregiver mental health. Results revealed that more patient Duchenne smiles were associated with better caregiver mental health. These findings generalized across diagnosis, and were specific to patient Duchenne smiles; no association was found between caregiver smiles (Duchenne or non-Duchenne) and caregiver mental health. When examining this association while accounting for covariates (i.e., diagnosis, patient cognitive functioning, and caregiver marital satisfaction), more patient Duchenne smiles remained a significant predictor of better caregiver mental health, and fewer patient non-Duchenne smiles became a significant predictor of worse caregiver mental health. Further analysis revealed that marital satisfaction, but not patient cognitive functioning, provided a likely suppressor effect in the association between greater patient non-Duchenne smiles and worse caregiver mental health. Finally, an exploratory analysis revealed that the association between patient Duchenne smiles and caregiver health was not mediated by caregiver marital satisfaction.

Although analyses revealed that marital satisfaction was not a significant mediator, both marital satisfaction and patient diagnosis were significant predictors of caregiver well-being. These findings support studies that have found marital satisfaction and marital quality to reduce negative affect (Carr, Cornman, & Freedman, 2016) and serve as key protective factors against the adverse effects of caregiver burden. For example, caregivers who report higher levels of marital satisfaction have been found to be less reactive to memory and behavioral changes in dementia patients and engage in better problem solving skills than caregivers who reported lower levels of marital satisfaction (Steadman, Tremont, & Duncan Davis, 2007). Similarly, several studies have found that patient diagnosis can also impact caregiver outcomes. Behavioral symptoms, such as apathy and disinhibition, which tend to have the greatest negative impact on caregiver outcomes (Merrilees et al., 2013; Mioshi et al., 2013), are more commonly observed in frontotemporal dementia than in AD. Thus, although our study revealed that patient smiles were positively associated with caregiver mental health even when accounting for patient diagnosis and caregiver marital satisfaction, it illuminates just one piece of the complex processes that influence caregivers' mental health.

Implications of Patient Duchenne Smiles and Caregiver Mental Health

Our findings indicate that the mental health of caregivers of patients with bvFTD and AD is associated with signs of genuine positive emotion expressed by the person in their care. However, the particular mechanisms driving this association are still unknown. Smiles serve many interpersonal functions. For example, Duchenne smiles convey affiliation, warmth, and intimacy (Hess, Beaupré, & Cheung, 2002), and elicit more positive judgments and more cooperation from others than do non-Duchenne smiles (Johnston et al., 2010). These functions may be particularly important in late life, because older adults have been found to appraise social rejection more negatively than younger adults (Cheng & Grühn, 2015), and a lack of affiliation has been linked with greater cognitive decline and dementia in late life (Rafnsson, Orrell, d'Orsi, Hogervorst, & Steptoe, 2017).

Extrapolating from these findings, for married couples where one spouse has dementia, Duchenne smiles expressed by the spouse with dementia may convey affiliation, which could have a soothing effect on the caregiver. Previous research has shown that affiliation can reduce stress and HPA activity (DeVries, Glasper, & Detillion, 2003), and that holding a spouse's hand reduces activity in brain regions associated with anxiety (Coan, Schaefer, & Davidson, 2006). Duchenne smiles may be another way in which partners affiliate and thereby soothe each other, which may be especially helpful for caregivers who are likely to be experiencing high levels of stress. Consistent with this, in previous studies with individuals and couples, we have found that the expression of positive emotions is associated with a reduction of autonomic nervous system arousal (Fredrickson & Levenson, 1998; Yuan, McCarthy, Holley, & Levenson, 2010).

Alternately, Duchenne smiles may serve to elicit greater cooperation from others (Johnston et al., 2010). Patients' Duchenne smiles may make spousal caregivers more willing to help the patient, thus helping caregivers feel less resentful of or trapped in their caregiving role, which could foster better mental health. Experiencing warmth and positive emotions has also been linked to caregiver satisfaction (Carruth, Tate, Moffett, & Hill, 1997), which in turn can increase caregiver mental health.

In the present study, we also found some evidence that more patient non-Duchenne smiles were associated with worse caregiver mental health. This finding only emerged when we accounted for differences in patient diagnosis, patient cognitive functioning, and caregiver marital satisfaction. Examining these covariates separately revealed that it was the inclusion of marital satisfaction that revealed the association between more non-Duchenne smiles by patients and worse caregiver mental health. These analyses suggest that higher marital satisfaction may serve as a particularly important buffer for maintaining caregiver mental health in relationships where the patient expresses greater smiles that are merely "polite" when communicating with their caregiver. The negative association between more non-Duchenne smiles and worse caregiver mental health is consistent with previous research that has found non-Duchenne smiles to be associated with more negative outcomes. For example, in healthy married couples, non-Duchenne smiles during a conversation were associated with more time separated over the following four years (Gottman, Levenson, & Woodin, 2001).

One striking non-finding in the present study was that caregiver smiles (Duchenne and non-Duchenne) were not associated with caregivers' mental health. We expected caregivers' positive emotional behavior to be related to their own mental health, consistent with research that has generally found positive emotion to serve as a protective buffer against negative outcomes (Fredrickson & Joiner, 2002). The association between positive emotional behavior and caregiver mental health may have been significant for patient positive emotional behavior, but not caregiver positive emotional behavior, due to the substantial impact that patient behaviors have on caregiver mental health. Many studies have found that behavioral symptoms in patients with dementia are most closely linked with adverse caregiver health outcomes (Schulz & Eden, 2016).

Our findings have a number of practical implications. Caregivers of dementia patients experience significant levels of burden and are vulnerable to declining mental health (Schulz & Eden, 2016). Interventions designed to prevent or treat these problems in caregivers could benefit from targeting specific factors, such as altering patient behaviors (e.g., reinforcing the expression of positive emotion) or compensating for related losses (e.g., support groups and friends becoming a source of emotionally positive interactions for caregivers). Given the effects positive emotions have on reducing autonomic arousal (Yuan et al., 2010), it may also be useful for caregiver interventions to incorporate components that focus on self-soothing, such as mindfulness exercises (Raes, Bruyneel, Loeys, Moerkerke, & De Raedt, 2015) and other individualized activities that can increase self-care. Finally, providing psychoeducation for caregivers concerning the likely reduction of positive emotion that will accompany disease progression can help caregivers understand that this reduction is not a deliberate behavior on the part of the patient. This understanding can help buffer caregivers from the frustration and sense of loss associated with diminished expression of positive emotion on the part of a loved one with dementia.

Strengths and Limitations

Strengths of this research include studying a community sample of participants with two different kinds of dementias, the use of objective behavioral measurement of positive emotions, and studying positive emotion in an ecologically valid semi-naturalistic interpersonal context. To our knowledge, this is the first study to use an objective behavioral measure to assess positive emotion in the interactions of couples where one spouse has dementia, and the first to link positive emotion measured in this manner with caregiver mental health.

The research also has several limitations. Although our sample size of 57 patient–caregiver dyads is relatively large compared to some laboratory studies that have examined dementia patients, sample size remains a limitation. *A priori* power analyses indicated that for power = 0.80 and four predictors, a sample size of 85 dyads would have been required to detect a small effect size. Thus, some of the associations that were non-significant within our sample may reach significance in larger samples with additional power. Other methodological limitations include our exclusive focus on positive emotion (we did not consider negative [e.g., anger, sadness] or self-conscious [e.g., shame, pride] emotional expressions), examining a brief, "thin slice" behavior (Ambady et al., 2000), using a cross-sectional rather than a longitudinal design, and not including a sample of

healthy control couples (which would help determine the extent to which findings are unique to couples dealing with dementia).

An additional limitation is that we cannot know with certainty whether observable Duchenne smiles are spontaneous, veridical indicators of participants' underlying positive emotional states, or are being produced strategically and deliberately (Gunnery, Hall, & Ruben, 2013). Although impairments in patients' cognitive, motor, and social functioning make this level of self-monitoring, voluntary control of facial behavior, and strategic impression management less likely (Gregory et al., 2002), it is still possible that patients are not actually experiencing positive emotion, but rather have learned to produce Duchenne smiles as a way of eliciting cooperation and reducing displeasure in caregivers.

Future Directions

In future studies, it will be important to extend this research to include other indicators of emotion (e.g., words, gestures), negative and self-conscious emotions, and other contexts (e.g., other kinds of conversations and shared activities). Similarly, it will be useful to examine these associations in patients with other dementias as well as psychiatric disorders.

Several timing issues are also important directions for future studies. Patients with dementia and other neurological diseases may react to social stimuli at a slower pace than adults without neurological disorders. No literature currently addresses this question, but it would be useful to determine whether patients show delayed emotional responses to stimuli, and whether those delays impact caregiver mental health. In addition, the present study focused on the initial segment of the conversation, which has previously been found to be related to relationship quality (Carrère & Gottman, 1999). However, future studies would benefit from examining emotional behavior during other parts of the conversation (e.g., the ending) as well as the trajectory of emotional changes over time.

It will also be important to consider possible mechanisms of the effects found in this study. Exploratory analyses in the present study suggest that marital satisfaction is not a likely mechanism undergirding the relationship between patient Duchenne smiles and caregiver mental health. Previous research has shown that Duchenne smiles elicit in others a greater willingness to cooperate (Johnston et al., 2010). When patients show more Duchenne smiles, caregivers may feel more willing to help the patient with activities of daily living instead of feeling obligated and trapped in the caregiving role, and may experience better mental health as a result. Thus, mechanisms such as caregivers' subjective experience of decreased burden, or increased positive emotion as the result of receiving Duchenne smiles will be important factors to examine. Additionally, data on HPA activity might reveal a mediating effect at the physiological level. Further research examining these mechanisms would help to clarify the association between patient Duchenne smiles and caregiver mental health.

In research with individuals with dementia, it is compelling to consider the disease as the primary cause of changes in patients' emotional behavior and the behavioral changes as the primary cause of changes in caregivers' mental health. Thus, we suspect that dementia is causing declining levels of patient Duchenne smiles, which cause declines in caregiver mental health. However, elements of this causal chain may function in the reverse direction (i.e., caregivers with worse mental health may cause patients to produce lower levels of Duchenne smiles). Evaluating these possibilities will require longitudinal designs that measure potential mediating mechanisms at multiple time-points.

Conclusion

The human face has an exquisitely tuned facial musculature that plays a crucial role in communicating our emotions. A Duchenne, or "genuine," smile, moves only two facial muscles—the orbicularis oculi (cheek raise) and zygomatic major (lip corner raise). Nonetheless, this kind of smile has been found to be associated with a number of positive outcomes including, in the present study, better mental health in spousal caregivers of dementia patients. Given the increasing prevalence of dementia and the rapidly growing aging population worldwide, understanding the role that positive emotional behaviors play in caregiver mental health has important implications for helping preserve the well-being of caregivers and for advancing our understanding of emotional expression and its effects on others.

Funding

This research was supported by National Institute on Aging grants 1R01AG041762-01A1 and 2P01AG019724-11 to R.W.L. and B.L.M.

Acknowledgements

S.J.L., J.J.C., J.M., and R.W.L. developed the study concept. S.J.L., J.J.C., A.V., and D.E.C. performed the facial coding. S.J.L. processed and analyzed the data. S.J.L. and J.J.C. wrote the first draft of the manuscript; and all authors contributed to revisions of the manuscript. R.W.L. supervised all phases of the project. S.J.L. and J.J.C. contributed equally to the study.

Conflict of Interest

There were no identified conflicts of interest.

References

Ambady, N., Bernieri, F. J., & Richeson, J. A. (2000). Toward a histology of social behavior: Judgmental accuracy from thin slices of the behavioral stream. In M. P. Zanna (Eds.), *Advances in experimental social psychology* (Vol. 32, pp. 201–271). San Francisco, CA: Academic Press.

Ascher, E. A., Sturm, V. E., Seider, B. H., Holley, S. R., Miller, B. L., & Levenson, R. W. (2010). Relationship satisfaction and emotional language in frontotemporal dementia and Alzheimer disease patients and spousal caregivers. *Alzheimer Disease and Associated Disorders*, **24**, 49–55. doi:10.1097/WAD.0b013e3181bd66a3

Blieszner, R., & Shifflett, P. A. (1990). The effects of Alzheimer's disease on close relationships between patients and caregivers. *Family Relations*, **39**, 57–62. doi:10.2307/584949

Bograd, R., & Spilka, B. (1996). Self-disclosure and marital satisfaction in mid-life and late-life remarriages. *International Journal of Aging & Human Development*, **42**, 161–172. doi:10.2190/W87M-WCK7-MHTT-N34F

Bourke-Taylor, H., Pallant, J. F., Law, M., & Howie, L. (2012). Predicting mental health among mothers of school-aged children with developmental disabilities: The relative contribution of child, maternal and environmental factors. *Research in Developmental Disabilities*, **33**, 1732–1740. doi:10.1016/j.ridd.2012.04.011

Braun, M., Mura, K., Peter-Wight, M., Hornung, R., & Scholz, U. (2010). Toward a better understanding of psychological well-being in dementia caregivers: The link between marital communication and depression. *Family Process*, **49**, 185–203. doi:10.1111/j.1545-5300.2010.01317.x

Campos, B., Shiota, M. N., Keltner, D., Gonzaga, G. C., & Goetz, J. L. (2013). What is shared, what is different? Core relational themes and expressive displays of eight positive emotions. *Cognition & Emotion*, **27**, 37–52. doi:10.1080/02699931.2012.683852

Carr, D., Cornman, J. C., & Freedman, V. A. (2016). Marital quality and negative experienced well-being: An assessment of actor and partner effects among older married persons. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, **71**, 177–187. doi:10.1093/geronb/gbv073

Carrère, S., & Gottman, J. M. (1999). Predicting divorce among newlyweds from the first three minutes of a marital conflict discussion. *Family Process*, **38**, 293–301. doi:10.1111/j.1545-5300.1999.00293.x

Carruth, A. K., Tate, U. S., Moffett, B. S., & Hill, K. (1997). Reciprocity, emotional well-being, and family functioning as determinants of family satisfaction in caregivers of elderly parents. *Nursing Research*, **46**, 93–100. doi:10.1097/00006199-199703000-00006

Cheng, Y., & Grühn, D. (2015). Age differences in reactions to social rejection: The role of cognitive resources and appraisals. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, **70**, 830–839. doi:10.1093/geronb/gbu054

Chopik, W. J., & O'Brien, E. (2017). Happy you, healthy me? Having a happy partner is independently associated with better health in oneself. *Health Psychology*, **36**, 21–30. doi:10.1037/hea0000432

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological Science*, **17**, 1032–1039. doi:10.1111/j.1467-9280.2006.01832.x

Coleman, M., Ganong, L., & Fine, M. (2000). Reinvestigating remarriage: Another decade of progress. *Journal of Marriage and Family*, **62**, 1288–1307. doi:10.1111/j.1741-3737.2000.01288.x

Cornwell, B., Laumann, E. O., & Schumm, L. P. (2008). The social connectedness of older adults: a national profile*. *American Sociological Review*, **73**, 185–203. doi:10.1177/000312240807300201

DeVries, A. C., Glasper, E. R., & Detillion, C. E. (2003). Social modulation of stress responses. *Physiology & Behavior*, **79**, 399–407. doi:10.1016/S0031-9384(03)00152-5

Ekman, P., & Friesen, W. V. (1977). *Facial action coding system*. Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Nonverbal Behavior*, **6**, 238–252. doi:10.1007/BF00987191

Ekman, P., & Rosenberg, E. L. (2005). *What the face reveals: Basic and applied studies of spontaneous expression using the facial action coding system (FACS)* (2nd ed.). New York, NY: Oxford University Press.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, **12**, 189–198. doi:10.1016/0022-3956(75)90026-6

Fredrickson, B. L. (2004). The broaden-and-build theory of positive emotions. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences*, **359**, 1367–1378. doi:10.1098/rstb.2004.1512

Fredrickson, B. L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological Science*, **13**, 172–175. doi:10.1111/1467-9280.00431

Fredrickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion*, **12**, 191–220. doi:10.1080/026999398379718

Fredrickson, B. L., Tugade, M. M., Waugh, C. E., & Larkin, G. R. (2003). What good are positive emotions in crises? A prospective study of resilience and emotions following the terrorist attacks on the United States on September 11th, 2001. *Journal of Personality and Social Psychology*, **84**, 365–376. doi:10.1037/0022-3514.84.2.365

Gonzaga, G. C., Keltner, D., Londahl, E. A., & Smith, M. D. (2001). Love and the commitment problem in romantic relations and friendship. *Journal of Personality and Social Psychology*, **81**, 247–262. doi:10.1037/0022-3514.81.2.247

Gottman, J., Levenson, R., & Woodin, E. (2001). Facial expressions during marital conflict. *Journal of Family Communication*, **1**, 37–57. doi:10.1207/S15327698JFC0101_06

Gregory, C., Lough, S., Stone, V., Erzinclioglu, S., Martin, L., Baron-Cohen, S., & Hodges, J. R. (2002). Theory of mind in patients with frontal variant frontotemporal dementia and Alzheimer's disease: Theoretical and practical implications. *Brain: A Journal of Neurology*, **125**, 752–764. doi:10.1093/brain/awf079

Gunnery, S. D., Hall, J. A., & Ruben, M. A. (2013). The deliberate Duchenne smile: Individual differences in expressive control. *Journal of Nonverbal Behavior*, **37**, 29–41. doi:10.1007/s10919-012-0139-4

Haase, C. M., Beermann, U., Saslow, L. R., et al. (2015). Short alleles, bigger smiles? The effect of 5-HTTLPR on positive emotional expressions. *Emotion (Washington, D.C.)*, **15**, 438–448. doi:10.1037/emo0000074

Harker, L., & Keltner, D. (2001). Expressions of positive emotion in women's college yearbook pictures and their relationship to personality and life outcomes across adulthood. *Journal of Personality and Social Psychology*, **80**, 112–124. doi:10.1037/0022-3514.80.1.112

Hawthorne, G., Osborne, R. H., Taylor, A., & Sansoni, J. (2007). The SF36 Version 2: Critical analyses of population weights, scoring algorithms and population norms. *Quality of Life Research*, **16**, 661–673. doi:10.1007/s11136-006-9154-4

Hayes, A. F. (2008). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Press.

Hess, U., Beaupré, M. G., & Cheung, N. (2002). Who to whom and why–cultural differences and similarities in the function of smiles. In M. Abel (Ed.), *An empirical reflection on the smile* (pp. 187–216). New York: Edwin Mellen Press.

Johnston, L., Miles, L., & Macrae, C. N. (2010). Why are you smiling at me? Social functions of enjoyment and non-enjoyment smiles. *The British Journal of Social Psychology*, **49**, 107–127. doi:10.1348/014466609X412476

Keltner, D., & Bonanno, G. A. (1997). A study of laughter and dissociation: Distinct correlates of laughter and smiling during bereavement. *Journal of Personality and Social Psychology*, **73**, 687–702. doi:10.1037/0022-3514.73.4.687

Kouros, C. D., Papp, L. M., & Cummings, E. M. (2008). Interrelations and moderators of longitudinal links between marital satisfaction and depressive symptoms among couples in established relationships. *Journal of Family Psychology*, **22**, 667–677. doi:10.1037/0893-3200.22.5.667

LaFrance, M., Hecht, M. A., & Paluck, E. L. (2003). The contingent smile: A meta-analysis of sex differences in smiling. *Psychological Bulletin*, **129**, 305–334. doi:10.1037/0033-2909.129.2.305

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology*, **45**, 587–597. doi:10.1037/0022-3514.45.3.587

Levenson, R. W., Haase, C., Bloch, L., Holley, S., & Seider, B. (2013). Emotion regulation in couples. In J. J. Gross (Ed.), *Handbook of emotion regulation* (2nd ed., pp. 267–283). New York: Guilford Press.

Levenson, R. W., Lwi, S. J., Brown, C. L., Ford, B. Q., Otero, M. C., & Verstaen, A. (2017). Emotion. In J. T. Cacioppo, L. G. Tassinary & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed.) (pp. 444–464). Cambridge: Cambridge University Press.

Lewis, R. J., Derlega, V. J., Griffin, J. L., & Krowinski, A. C. (2003). Stressors for gay men and lesbians: Life stress, gay-related stress, stigma consciousness, and depressive symptoms. *Journal of Social and Clinical Psychology*, **22**, 716–729. doi:10.1521/jscp.22.6.716.22932

Lints-Martindale, A. C., Hadjistavropoulos, T., Barber, B., & Gibson, S. J. (2007). A psychophysical investigation of the facial action coding system as an index of pain variability among older adults with and without Alzheimer's disease. *Pain Medicine (Malden, Mass.)*, **8**, 678–689. doi:10.1111/j.1526-4637.2007.00358.x

Locke, H. J., & Wallace, K. M. (1959). Short marital-adjustment and prediction tests: Their reliability and validity. *Marriage and Family Living*, **21**, 251–255. doi:10.2307/348022

Losada, M., & Heaphy, E. (2004). The role of positivity and connectivity in the performance of business teams: A nonlinear dynamics model. *American Behavioral Scientist*, **47**, 740–765. doi:10.1177/0002764203260208

Mahoney, R., Regan, C., Katona, C., & Livingston, G. (2005). Anxiety and depression in family caregivers of people with Alzheimer disease: The LASER-AD study. *The American Journal of Geriatric Psychiatry*, **13**, 795–801. doi:10.1097/00019442-200509000-00008

McHorney, C. A., Ware, J. E. Jr, & Raczek, A. E. (1993). The MOS 36-item short-form health survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Medical Care*, **31**, 247–263. doi:10.1097/00005650-199303000-00006

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspices of department of health and human services task force on Alzheimer's disease. *Neurology*, **34**, 939–944. doi:10.1212/WNL.34.7.939

Merrilees, J., Dowling, G. A., Hubbard, E., Mastick, J., Ketelle, R., & Miller, B. L. (2013). Characterization of apathy in persons with frontotemporal dementia and the impact on family caregivers. *Alzheimer Disease and Associated Disorders*, **27**, 62–67. doi:10.1097/WAD.0b013e3182471c54

Mioshi, E., Foxe, D., Leslie, F., Savage, S., Hsieh, S., Miller, L., … Piquet, O. (2013). The impact of dementia severity on caregiver burden in frontotemporal dementia and Alzheimer disease. *Alzheimer Disease and Associated Disorders*, **27**, 68–73. doi:10.1097/WAD.0b013e318247a0bc

Nunnemann, S., Kurz, A., Leucht, S., & Diehl-Schmid, J. (2012). Caregivers of patients with frontotemporal lobar degeneration: A review of burden, problems, needs, and interventions. *International Psychogeriatrics*, **24**, 1368–1386. doi:10.1017/S104161021200035X

Raes, A. K., Bruyneel, L., Loeys, T., Moerkerke, B., & De Raedt, R. (2015). Mindful attention and awareness mediate the association between age and negative affect. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, **70**, 181–190. doi:10.1093/geronb/gbt074

Rafnsson, S. B., Orrell, M., d'Orsi, E., Hogervorst, E., & Steptoe, A. (2017). Loneliness, social Integration, and incident dementia over 6 years: Prospective findings from the English Longitudinal Study of Ageing. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. **0**, 1–11. doi:10.1093/geronb/gbx087

Rascovsky, K., Hodges, J. R., Knopman, D., Mendes, M. F., Kramer, J. H., Neuhaus, J., … Miller, B. L. (2011). Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. *Brain*, **134**, 2456–2477. doi:10.1093/brain/awr179

Schulz, R., & Eden, J. (2016). *Families caring for an aging America*. Washington, DC: The National Academies Press.

Schulz, R., O'Brien, A. T., Bookwala, J., & Fleissner, K. (1995). Psychiatric and physical morbidity effects of dementia caregiving: Prevalence, correlates, and causes. *The Gerontologist*, **35**, 771–791. doi:10.1093/geront/35.6.771

Schulz, R., & Sherwood, P. R. (2008). Physical and mental health effects of family caregiving. *The American Journal of Nursing*, **108**, 23–7; quiz 27. doi:10.1097/01.NAJ.0000336406.45248.4c

Seeley, W. W., Allman, J. M., Carlin, D. A., Crawford, R. K., Macedo, M. N., Greicius, M. D., Dearmond, S. J., … Miller, B. L. (2007). Divergent social functioning in behavioral variant frontotemporal dementia and Alzheimer disease: reciprocal networks and neuronal evolution. *Alzheimer Disease and Associated Disorders*, **21**, S50–S57. doi:10.1097/WAD.0b013e31815c0f14

Steadman, P. L., Tremont, G., & Davis, J. D. (2007). Premorbid relationship satisfaction and caregiver burden in dementia caregivers. *Journal of Geriatric Psychiatry and Neurology*, **20**, 115–119. doi:10.1177/0891988706298624

Strathearn, L., Li, J., Fonagy, P., & Montague, P. R. (2008). What's in a smile? Maternal brain responses to infant facial cues. *Pediatrics*, **122**, 40–51. doi:10.1542/peds.2007-1566

Sturm, V. E., McCarthy, M. E., Yun, I., Madan, A., Yuan, J. W., Holley, S. R., … Levenson, R. W. (2011). Mutual gaze in Alzheimer's disease, frontotemporal and semantic dementia couples. *Social Cognitive and Affective Neuroscience*, **6**, 359–367. doi:10.1093/scan/nsq055

Tarlov, A. R., Ware, J. E. Jr, Greenfield, S., Nelson, E. C., Perrin, E., & Zubkoff, M. (1989). The medical outcomes study. An application of methods for monitoring the results of medical care. *JAMA*, **262**, 925–930. doi:10.1001/jama.1989.03430070073033

Ware, J. (2000). SF-36 health survey update. *Spine*, **25**, 3130–3139. doi:10.1097/00007632-200012150-00008

Ware, J. E., Kosinski, M., & Keller, S. (1994). *SF-36 physical and mental health summary scales: A user's manual*. Health Assessment Lab. Boston, MA: Health Institute, New England Medical Center.

Wichers, M. C., Myin-Germeys, I., Jacobs, N., Peeters, F., Kenis, G., Derom, C., … van Os, J. (2007). Evidence that moment-to-moment variation in positive emotions buffer genetic risk for depression: A momentary assessment twin study. *Acta Psychiatrica Scandinavica*, **115**, 451–457. doi:10.1111/j.1600-0447.2006.00924.x

Yuan, J. W., McCarthy, M., Holley, S. R., & Levenson, R. W. (2010). Physiological down-regulation and positive emotion in marital interaction. *Emotion (Washington, D.C.)*, **10**, 467–474. doi:10.1037/a0018699

Zhu, Y. X., Li, T., Fan, S. R., Liu, X. P., Liang, Y. H., & Liu, P. (2016). Health-related quality of life as measured with the Short-Form 36 (SF-36) Questionnaire in patients with recurrent vulvovaginal candidiasis. *Health and Quality of Life Outcomes*, **14**, 65. doi:10.1186/s12955-016-0470-2