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Research Article

Rich and Balanced Experiences of Daily Emotions Are Associated With Activity Diversity Across Adulthood

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Abstract

Objectives: Studies demonstrate the association between diverse emotions and health. However, we know little about how these emotions are related to activities in daily life. This study examined whether the diversity of daily activities ("activity diversity") is associated with the diversity of both positive and negative daily emotions ("emodiversity") in adulthood. We also examined if these associations differed by age.

Method: 2 separate samples of participants from the Midlife in the United States Study II (M2: 2004–2009, n = 2,012, M_{age} = 56 years) and Refresher (MR: 2012–2016, n = 779, M_{age} = 47 years) provided activity and emotion data for 8 consecutive days. Using Shannon's entropy, we constructed activity diversity and emodiversity (positive, negative) scores. Analyses adjusted for sociodemographic and health characteristics, total activity time, mean positive/negative emotions, and number of days with positive/negative emotion data.

Results: Greater activity diversity was associated with greater positive emodiversity and greater negative emodiversity in both samples. In the M2 sample, the association between activity diversity and positive emodiversity was stronger among relatively younger adults, such that the positive association among those aged 33–44 years was greater than that observed among those aged 68–84 years. Results held after adjusting for time spent in each of the activities or when using different emodiversity metrics (Gini or Simpson coefficients).

Discussion: Broad and even participation of daily activities may provide more opportunities to experience rich and balanced emotions. Findings suggest that the association between activity diversity and emodiversity exists across adulthood, underscoring the value of including information about daily activities when examining emotional experiences across the life span.

Keywords: Active lifestyle, Activity variety, Age differences, Diverse emotions, Emotional complexity

Researchers have discussed the importance of experiencing a diversity of positive emotions (Ong et al., 2018; Quoidbach et al., 2014; Urban-Wojcik et al., 2020) and in some cases a diversity of negative emotions (Benson et al., 2018; Quoidbach et al., 2014) in association with better health. For example, experiencing a broad spectrum of positive emotions (e.g., cheerful, satisfied, and enthusiastic feelings) with even frequency is related to health above and beyond just feeling more cheerful on average (e.g., see Urban-Wojcik et al., 2020). Likewise,

feeling a broad spectrum of negative emotions with even frequency may indicate having experienced and appraised a variety of situations, which may help develop a more balanced and nuanced perspective. However, we know little about how these diverse emotions are elicited in natural environments. Most theories of emotion emphasize that emotions are elicited by stimuli, so it may be that a broad range of emotions may be linked with a broad range of activities. This paper examines whether broad and even participation of daily activities such as exercising, volunteering, and time with children ("activity diversity") is related to experiencing rich and balanced emotions ("emodiversity") in adulthood and if this association differs by age.

Research shows that experiencing a variety of emotions is generally related to better health outcomes. For example, greater positive emodiversity is associated with lower risk of inflammation (Ong et al., 2018), fewer symptoms of mental illness and physical health (Quoidbach et al., 2014; Urban-Wojcik et al., 2020), and wiser reasoning (Grossmann et al., 2019). Findings on negative emodiversity, however, are mixed. Some report no effects of negative emodiversity (Ong et al., 2018), while others report positive effects (Benson et al., 2018; Quoidbach et al., 2014) or a combination of positive and negative effects (Urban-Wojcik et al., 2020). Although the health effects of negative emodiversity seem to vary depending on specific outcomes of interest, both positive and negative emodiversity are assumed to indicate a rich and balanced emotional life (Benson et al., 2018; Grossmann et al., 2019; Quoidbach et al., 2014, 2018). Even for negative emotions, overabundance of singular emotions across situations (thus lack of diversity) may not be adaptive. For example, feeling intense anger across situations may mean that the individual has a narrow appraisal of situations, whereas feeling a mix of anger, sadness, and shame may indicate a broader and more nuanced appraisal.

We posit that activity diversity provides a context in which emotions are elicited. Although the reverse can also be true (e.g., more positive emotions may lead to engaging in diverse activities), we base our premise on theories suggesting that emotions evolved over the millennia to provide flexible and adaptive responses to ever changing environments. The psychological construction view suggests that emotions are constructed by a combination of internal states/knowledge and external events (Barrett, 2013; Boiger & Mesquita, 2012; Russell, 2003). Specifically, emotional episodes are constructed when internal bodily sensations (e.g., changes in heart rate or feelings) are perceived as causally related to surrounding events with conceptual knowledge stored from past experience (Barrett, 2013). Thus, a variety of emotions may result from diverse external activities and associated internal learnings. Further, according to appraisal theories of emotions, appraisals of features in the environment generate emotions (Frijda, 1986; Moors et al., 2013; Roseman, 1984). People may also discover novel lines of behavior to broaden their emotional experiences, or they may engage in activities that elicit diverse emotions (cf. Fredrickson, 2001). As a result, greater variation in daily activities (i.e., activity diversity) may explain why some people have greater positive or negative emodiversity than others.

The literature suggests that activity diversity supports health and well-being. For example, greater activity diversity is associated with higher psychological well-being, better cognitive functioning, and greater hippocampal volume (Bielak et al., 2019a; Lee et al., 2018, 2020; Urban-Wojcik et al., in press). Researchers have used many theories, such as social integration and cognitive reserve, to explain how activity diversity provides opportunities to accumulate social and intellectual repertoires, all of which benefit health and well-being (Beadle, 2019; Chan et al., 2019; Cohen et al., 2000; Molesworth et al., 2015; Moored et al., 2020; Scarmeas & Stern, 2003; Stern, 2002). Activity diversity may also provide emotional experiences that benefit one's health.

There is no research that we are aware of linking activity diversity and emodiversity, but previous studies on daily activities and affective well-being provide insight into their relationship. A greater variety of daily activities is associated with more positive emotions (but not less negative emotions) in U.S. older adults (Fingerman et al., 2020). Among people with physical or mental health issues, greater time spent in one-on-one interactions or physical activities is associated with higher scores for both valence and arousal of nine positive and negative emotions (Nandy et al., 2019). Although these studies assess the valence and level of emotions rather than the diversity and spread of emotional experiences, the overall findings suggest that activity diversity provides more opportunities for both positive and negative emotions. Variability in daily activities is also related to variability in daily cognitive performance (Bielak et al., 2019b), which is posited to relate to enhanced perspective-taking and thus to the likelihood of experiencing diverse emotions (Charles et al., 2017; Magai et al., 2006).

In examining the association between activity diversity and emodiversity, it is important to consider age differences. In accordance with the socioemotional selectivity theory, older adults may be motivated to reduce the size of their social network and related activities partly to avoid potentially negative emotional experiences (Carstensen et al., 2003; Lee et al., 2018), which may lead to a reduction in activity diversity. Age is also related to less negative emodiversity and more positive emodiversity (Urban-Wojcik et al., 2020), although its correlation with positive emodiversity seems weak (Ong et al., 2018). Together, age-related trends in activity diversity and emodiversity suggest that younger and older adults may differ in how the two diversity indices are related to each other in their lives. Given the paucity of research on this topic, we explore differences by age, rather than testing a specific hypothesis.

Present Study

Participants and Procedures

The current study examined the associations of activity diversity with positive and negative emodiversity in two independent samples of U.S. adults. Using Shannon's (1948) entropy that captures the breadth (i.e., number) and evenness (i.e., frequency) of each experience, we hypothesized that greater activity diversity would be associated with greater positive emodiversity and greater negative emodiversity. Then, we explored whether these potential associations would differ in strength and/or direction by age. To rule out potential confounds, we adjusted for sociodemographic and health covariates, total activity time, mean positive or negative emotions, and total number of days with data on positive or negative emotions in our analyses. Our study plan and hypotheses were preregistered here: https://osf.io/k38dr.

Method

Participants and Procedure

Data for the current study were drawn from the Midlife in the United States Study (MIDUS). Comprehensive details of the design and sample can be found elsewhere (Ryff & Krueger, 2018). Two independent MIDUS samples were used for the current analyses: the MIDUS II (M2) sample and the MIDUS Refresher (MR) sample. The M2 sample was collected between 2004 and 2009 as a longitudinal follow-up of the original MIDUS I sample. The MR sample was collected between 2012 and 2016 to refresh and expand the MIDUS by recruiting a new set of participants (Kirsch & Ryff, 2016; Surachman et al., 2019). For the purposes of the present study, we used subsamples of M2 and MR who participated in the daily diary portion of MIDUS, or National Study of Daily Experiences (NSDE), as well as the main survey.

During the M2 phase, 2,022 individuals who completed the main survey were invited to participate in the NSDE-II, an 8-day daily diary. After excluding those who did not provide data on daily activities (n = 1), positive emotions (n = 9) or negative emotions (n = 0) across the study days, the final analytic sample for the M2 included 2,012 individuals. During the MR phase, 782 individuals were invited to participate in both the MR main survey and the NSDE-R. After excluding those who did not provide data on daily activities (n = 0), positive emotions (n = 2), or negative emotions (n = 1) across the study days, the final analytic sample for the MR consisted of 779 individuals. These sample sizes were thought to be sufficient to test hypotheses in each sample. The G*Power analysis (Faul et al., 2007) suggested a minimum sample size of n = 652 to use a general linear model when the effect of activity diversity predicting positive or negative emodiversity is assumed to be small (0.02) with the alpha error probability of .05 and 10 assumed covariates.

Participants reported daily activities and emotions during each end-of-day telephone interview over 8 consecutive diary days. The mean number of diary days completed was 7.38 (SD = 1.27) in M2 and 7.89 (SD = 0.42) in MR. Most participants completed seven to eight diary interviews (87% and 98% in M2 and MR, respectively). The high diary completion rates suggested that most participants provided emotion and activity information on the same days.

We included some participants who provided emotion and activity data on separate days, because our measures of activity diversity and emodiversity were between-person level variables averaged across days.

Table 1 shows the characteristics of M2 and MR participants. Participants in M2 (n = 2,012; 43% men) ranged in age from 33 to 84 (M = 56). Those in MR (n = 779; 44% men) ranged in age from 25 to 75 (M = 47). Although there were some differences between the samples, overall the characteristics indicated that the two samples represent middle-aged, well-educated, and relatively healthy U.S. adults. The MIDUS protocol was approved by the University of Wisconsin–Madison Institutional Review Board (IRB). Written informed consent was received for all MIDUS participants. The current study was exempt from an IRB review due to our use of publicly available, deidentifiable data.

Measures

Activity diversity

During each end-of-day interview in NSDE, individuals were asked, "Since this time yesterday, how much time did you spend _____," reporting the hours and minutes they spent in seven activities: doing paid work, with children, doing chores, on leisure, in physical activities, on formal volunteering, and giving informal help to people who do not live with respondents (e.g., friends, neighbor, parent, other relatives, etc.). We did not include passive activities (e.g., receiving help) or routine activities (e.g., sleep). To gauge whether individuals had (=1) or had not (=0) participated in an activity on a given day, times were converted to a set of binary variables. After this, the number (i.e., breadth) and proportion (i.e., evenness) of each binary variable across all days were calculated and then used to measure *activity diversity*, calculated using Shannon's (1948) entropy as used in previous studies (Lee et al., 2018, 2020; Urban-Wojcik et al., in press).

$$Activity\quad Diversity_i = -\left(\frac{1}{\ln(m)}\right)\sum_{j=1}^{m} p_{ij}\ln p_{ij}$$

where m = 7 is the number of activity types, and p_{ij} is the proportion of individual i's reported frequency of each activity type to their total activity frequency, j = 1 to m. Activity diversity scores (transformed to %) could range

Table 1. Descriptive Characteristics of Two Samples

	MIDUS II (n = 2,012)[2]		MIDUS Refresher (n = 779)		Difference test[3]	p value
	M or %	*SD*	*M* or %	SD		
Demographic and heath covariates						
Age	56.21	12.20	47.86	12.66	16.06	<.001
Sex, male	43%		44%		0.64	.424
Race, White	84%		85%		0.12	.730
Education[1]	7.26	2.52	8.01	2.44	−7.16	<.001
Physical health	3.56	1.01	3.57	1.09	−0.10	.917
Main variables						
Activity diversity	71.72	14.48	73.35	12.82	−2.92	<.001
Total activity time (in hours)	11.61	4.71	12.40	4.22	−4.28	<.001
Positive emodiversity	95.79	7.75	94.98	8.00	2.47	.013
Mean positive emotions	2.72	0.71	2.53	0.75	6.38	<.001
Total # of days with positive emotions	7.24	1.39	7.30	1.58	−0.82	.415
Negative emodiversity	19.47	19.71	23.07	21.04	−4.13	<.001
Mean negative emotions	0.21	0.28	0.23	0.29	−1.94	.052
Total # of days with negative emotions	7.35	1.30	7.36	1.51	−0.22	.823

Notes: MIDUS = Midlife in the United States Study.
[1]Education was coded on a 12-level scale, where 7 means 3 or more years of college education (no degree yet) and 8 means graduated from 2-year college, vocational school, or have an associate degree.
[2]Of 2,012 MIDUS II sample, n = 179 (9%) were Milwaukee subsample. We controlled for Milwaukee subsample (vs not) in subsequent analyses using MIDUS II data. The nature of all effects was consistent with and without the Milwaukee subsample. There was no Milwaukee subsample who participated in the diary study of MIDUS Refresher.
[3]t-Tests were used for continuous variables; chi-squared tests were used for categorical variables.

from 0 (*no diversity*—all daily activity in a single category) to 100 (*complete diversity*—daily activity spread evenly across all categories).

Emodiversity

During the same 8-day interviews in NSDE, participants reported the frequency of emotions experienced each day. The emotion items were selected using a combination of the Positive and Negative Affect Schedule (Watson et al., 1988) and the Non-Specific Psychological Distress Scale (Kessler et al., 2002). Participants rated their experience of 13 positive emotions (feeling cheerful, in good spirits, extremely happy, calm and peaceful, satisfied, full of life, enthusiastic, attentive, proud, active, close to others, like you belong, and confident) and 14 negative emotions (feeling worthless, so sad nothing could cheer you up, nervous, restless or fidgety, hopeless, that everything was an effort, afraid, jittery, irritable, ashamed, upset, lonely, angry, and frustrated). We created positive emodiversity and negative emodiversity separately using Shannon's (1948) entropy, following several studies on emodiversity (Quoidbach et al., 2014, 2018; Urban-Wojcik et al., 2020). There are other diversity metrics, such as the Gini coefficient and the Simpson coefficient (Benson et al., 2018; Budescu & Budescu, 2012; Ong et al., 2018), but we selected Shannon's (1948) entropy to capture both the number (i.e., richness) and proportion (i.e., evenness) of emotions and to use a consistent method used in the calculation of activity diversity (see "Supplemental Analysis" section for results using these other diversity metrics). The experience of each emotion type on a given day was measured on a 0 (*none of the time*) to 4 (*all of the time*) frequency scale. The sum and proportion of each emotion type was calculated for each study day and then averaged across days. The formula for calculating positive emodiversity is expressed as:

$$Positive\quad Emotional\quad Diversity_i = -\left(\frac{1}{\ln(m)}\right)\sum_{j=1}^{m} p_{ij}\ln p_{ij}$$

where m = 13 is the number of positive emotions, and p_{ij} is the proportion of individual i's reported frequency of each positive emotion type to their total positive emotion frequency for the day, j = 1 to m. Positive emodiversity scores (transformed to %) could range from 0 to 100 and higher scores indicated greater positive emodiversity. Negative emodiversity score was similarly calculated where m = 14 as there were 14 negative emotion items.

Covariates

Sociodemographic characteristics known to be related to activity diversity and emodiversity (Lee et al., 2018, 2020; Urban-Wojcik et al., 2020) were preregistered and included as covariates. They included age (in years), sex (0 = *female*, 1 = *male*), race (0 = *non-White*, 1 = *White*), and education (1 = *no school/some grade school* to 12 = *PhD or other professional degree*). We also controlled for self-reported physical health (1 = *poor* to 5 = *excellent*) because perceived health may influence the extent of activity engagement and

emotional experiences. To rule out potential confounds and isolate the unique association of activity diversity with emodiversity, we included an individual's mean total time spent in the seven activities (total activity time, in hours), mean positive or negative emotions, and the total number of days that the participant had positive or negative emotions in all analyses. Additionally, we controlled for sample identifiers (Milwaukee vs non-Milwaukee of M2, and M2 vs MR) where relevant. We controlled for Milwaukee subsample identifier to account for differences in sampling strategy from the main sample. Continuous covariates were centered at the sample means.

Statistical Analysis

First, we used descriptive statistics to compare differences between the two samples (M2 and MR). Second, we used general linear regression models with PROC GLM in SAS (Fitzmaurice et al., 2004) to test our hypotheses regarding the associations of activity diversity with positive or negative emodiversity, adjusting for covariates. Third, we added an interaction between activity diversity and age in each model to explore potential moderation by age. Significant interactions ($p < .05$) were probed to understand the nature of the interactions. Simple slope tests were conducted using estimates commands in PROC GLM to compare differences in the associations between older (+1 *SD*) and younger (−1 *SD*) adults (Cohen et al., 2013). The term "younger adults" refers to relatively younger participants in the MIDUS samples, although the age range of 30–45 reflects "established adults" (Mehta et al., 2020). Analyses were performed in each sample.

All participants provided activity diversity and emodiversity data, but some individuals were missing covariate data. In M2, there were cases with incomplete data due to missingness in education ($n = 4$), and self-rated physical health ($n = 1$). In MR, there were cases with incomplete data due to missingness in race ($n = 4$). As the percentage with missing data in each sample was very small (<0.01%), these cases were excluded from the analyses.

Results

Descriptive Statistics

Table 1 shows the formal tests of sample differences (M2 vs MR) in variables of interest. Compared to M2 participants, MR participants were younger and had higher education levels, on average. Average levels of activity diversity and negative emodiversity were higher in MR than in M2. Mean positive emodiversity was higher in M2 than in MR. Age was negatively correlated with activity diversity in M2 and MR samples ($r = -.34$ and $-.27$, respectively, $ps < .001$). We compared proportion of older (≥ +1 *SD*) and relatively younger (≤ −1 *SD*) adults among those with higher (≥ +1 *SD*) or lower (≤ −1 *SD*) activity diversity in each sample. Of the M2 participants with higher activity diversity, 7% were older adults and 31% were younger adults; of the M2 participants with lower activity diversity, 34% were older adults and 9% were younger adults. Of the MR participants with higher activity diversity, 4% were older adults 24% were younger adults; of the MR participants with lower activity diversity, 39% were older adults and 13% were younger adults. Age was also associated with the seven activities we used to operationalize activity diversity. For example, age was negatively associated with total time spent in the seven daily activities in M2 and MR samples ($r = -.39$ and $-.29$, respectively, $ps < .001$), and this was mostly due to time spent at work ($r = -.50$ and $-.37$, respectively, $ps <$

Table 2. Results of General Linear Models Examining the Association of Activity Diversity With Positive Emodiversity

	MIDUS II ($n = 2,012$)					MIDUS Refresher ($n = 779$)				
	B	*SE*	*p* value	95% CI	β	*B*	*SE*	*p* value	95% CI	β
Intercept	96.44	0.47	<.001	[95.52, 97.35]	0.00	94.09	0.53	<.001	[93.06, 95.12]	0.00
Activity diversity	0.05	0.01	<.001	[0.03, 0.07]	0.09	0.08	0.02	<.001	[0.04, 0.12]	0.13
Total activity time	−0.06	0.03	.067	[−0.12, 0.004]	−0.04	**−0.13**	**0.06**	**.025**	**[−0.24, −0.02]**	**−0.07**
Mean positive emotions	**7.16**	**0.19**	**<.001**	**[6.79, 7.52]**	**0.66**	**7.65**	**0.28**	**<.001**	**[7.1, 8.21]**	**0.72**
Total # of days with positive emotions	0.02	0.09	.803	[−0.16, 0.2]	0.00	−0.14	0.13	.270	[−0.39, 0.11]	−0.03
Milwaukee (vs not) within MIDUS II	**−1.38**	**0.60**	**.022**	**[−2.56, −0.2]**	**−0.05**	—	—	—	—	—
Age	−0.01	0.01	.534	[−0.03, 0.02]	−0.01	−0.03	0.02	.096	[−0.06, 0.01]	−0.04
Male (vs female)	0.29	0.25	.255	[−0.21, 0.78]	0.02	**0.80**	**0.40**	**.046**	**[0.01, 1.58]**	**0.05**
White (vs non-White)	−0.75	0.47	.114	[−1.67, 0.18]	−0.04	0.64	0.55	.250	[−0.45, 1.72]	0.03
Education	0.00	0.05	.997	[−0.1, 0.1]	0.00	**0.20**	**0.09**	**.018**	**[0.04, 0.37]**	**0.06**
Physical health	**0.54**	**0.14**	**<.001**	**[0.27, 0.81]**	**0.07**	0.33	0.20	.100	[−0.06, 0.73]	0.05
Fit statistics										
F test	187.77		<.001			100.94		<.001		

Notes: MIDUS = Midlife in the United States Study. $n = 2,007$; 775 were used in the models for MIDUS II and MIDUS Refresher, respectively, due to missing values in covariates. Significant associations (at $p < .05$) are bolded.

.001) and time spent with children (r = –.34 and –.45, respectively, ps < .001) that may generally decrease with age. Although the correlations between age and other activities were either weak or not significant (.02 ≤ r ≤ .24), some of these differences by age suggested the need to consider age as a key covariate as well as a potential modifier.

Association Between Activity Diversity and Positive Emodiversity

Table 2 shows results from linear regression models examining the association of activity diversity with positive emodiversity separately in M2 and MR. Beginning with results on the M2 sample, greater activity diversity was associated with greater positive emodiversity, independently of the covariates: total activity time, mean positive emotions, total number of days with positive emotions, subsample identifier (Milwaukee vs not), and sociodemographic and health variables. Except the strong association of mean positive emotions with positive emodiversity (β = 0.66, p < .001), the effect size of activity diversity was the largest (β = 0.09, p < .001). Results were replicated and even stronger in the MR sample. Greater activity diversity was consistently associated with greater positive emodiversity (β = 0.13, p < .001), adjusting for all covariates.

Association Between Activity Diversity and Negative Emodiversity

Table 3 presents results from linear regression models examining the association of activity diversity with negative emodiversity. Results from the M2 sample showed that greater activity diversity was associated with greater negative emodiversity, even after adjusting for total activity time, mean negative emotions, total number of days with negative emotions, subsample identifier (Milwaukee vs not), and sociodemographic and health covariates. The effect size of activity diversity was comparable to the effect size of age, such that 1 *SD* increase in age was associated with 0.04 *SD* decrease in negative emodiversity, whereas 1 *SD* increase in activity diversity was associated with 0.05 *SD* increase in negative emodiversity. Again, results were replicated and even stronger in the MR sample. Greater activity diversity was associated with greater negative emodiversity (β = 0.07, p < .001), adjusting for all covariates.

Moderation by Age

In fully adjusted models, age moderated one of the associations in the M2 sample, but not in the MR sample (Figure 1), as indicated by a significant interaction between activity diversity and age predicting positive emodiversity (B = –0.003, SE = 0.001, p < .001). Simple slope tests indicated that the association between activity diversity and positive emodiversity was significant for both older adults (+1 *SD* or 68 years old; slope estimate = 0.03, SE = 0.01, p = .017) and younger adults (–1 *SD* or 44 years old; slope estimate = 0.10, SE = 0.02, p < .001), but the slope was stronger for younger adults (p < .001). In the model examining negative emodiversity, activity diversity did not interact with age (B = –0.002, SE = 0.001, p = .095). The association between activity diversity and negative emodiversity was significant for younger adults (slope estimate = 0.10, SE = 0.03, p < .001) and older adults (slope estimate = 0.05, SE = 0.02, p = .008), with no difference by age. As shown in Figure 1, analyses using the MR sample found no age moderation, with activity diversity associated with positive or negative emodiversity similarly for both younger (–1 *SD* or 35 years old) and older adults (+1 *SD* or 60 years old).

Table 3. Results of General Linear Models Examining the Association of Activity Diversity with Negative Emodiversity

	MIDUS II (n = 2,012)					MIDUS Refresher (n = 779)				
	B	SE	p value	95% CI	β	B	SE	p value	95% CI	β
Intercept	18.96	0.82	<.001	[17.36, 20.56]	0.00	21.97	1.03	<.001	[19.94, 23.99]	0.00
Activity diversity	0.07	0.02	<.001	[0.03, 0.1]	0.05	0.12	0.04	.001	[0.05, 0.19]	0.07
Total activity time	0.04	0.06	.504	[–0.07, 0.15]	0.01	0.09	0.11	0.411	[–0.13, 0.31]	0.02
Mean negative emotions	**63.68**	**0.87**	**<.001**	**[61.98, 65.38]**	**0.88**	**61.64**	**1.39**	**<.001**	**[58.91, 64.36]**	**0.84**
Total # of days with negative emotions	**1.36**	**0.18**	**<.001**	**[1.01, 1.71]**	**0.09**	0.20	0.26	.449	[–0.32, 0.71]	0.01
Milwaukee (vs not) within MIDUS II	**–3.17**	**1.06**	**.003**	**[–5.25, –1.09]**	**–0.05**	—	—	—	—	—
Age	**–0.07**	**0.02**	**<.001**	**[–0.11, –0.03]**	**–0.04**	**–0.12**	**0.03**	**.000**	**[–0.18, –0.06]**	**–0.07**
Male (vs female)	0.15	0.44	.726	[–0.71, 1.02]	0.00	–0.55	0.78	.481	[–2.09, 0.99]	–0.01
White (vs non-White)	0.89	0.83	.280	[–0.73, 2.52]	0.02	1.63	1.08	.133	[–0.5, 3.76]	0.03
Education	**0.30**	**0.09**	**.001**	**[0.12, 0.47]**	**0.04**	**0.63**	**0.17**	**.000**	**[0.3, 0.96]**	**0.07**
Physical health	**–0.82**	**0.23**	**<.001**	**[–1.28, –0.36]**	**–0.04**	–0.65	0.39	.098	[–1.41, 0.12]	–0.03
Fit statistics										
F test	632.94		<.001			249.95		<.001		

Notes: MIDUS = Midlife in the United States Study. n = 2,007; 775 were used in the models for MIDUS II and MIDUS Refresher, respectively, due to missing values in covariates. Significant associations (at p < .05) are bolded.

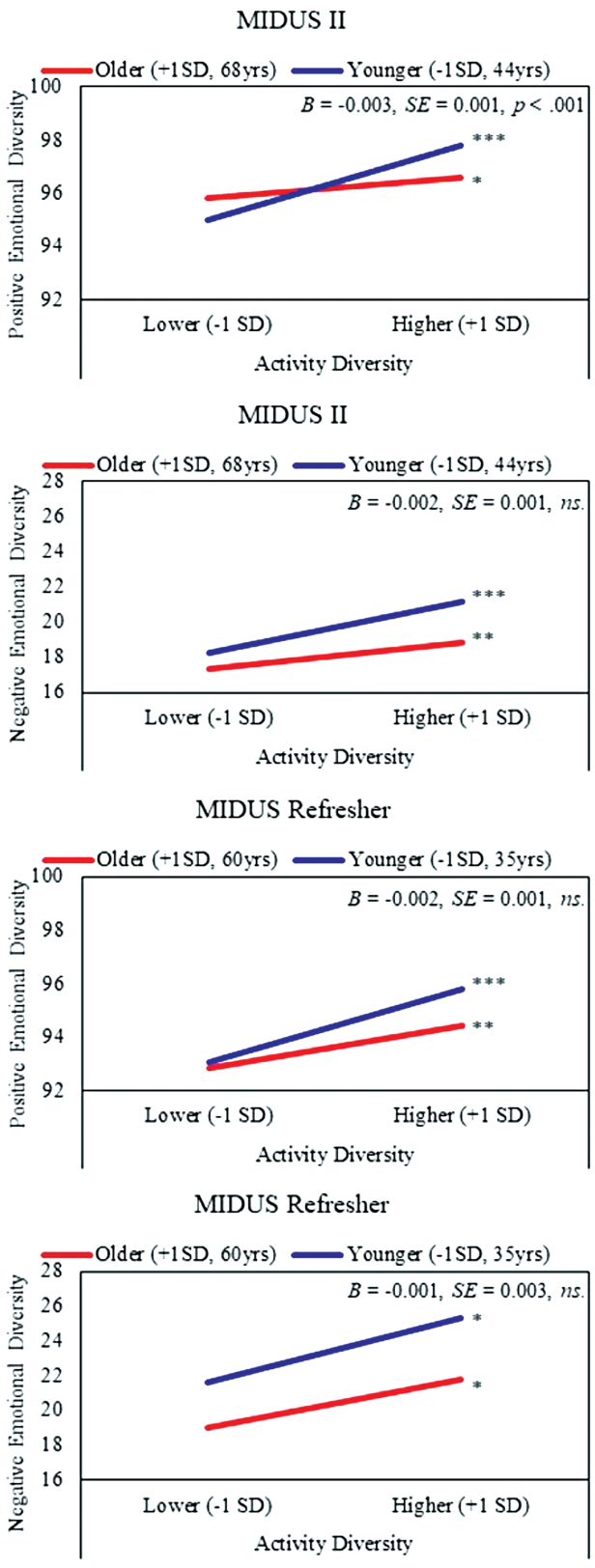

Figure 1. Moderation by age in the associations between activity diversity and emodiversity. *p < .05, **p < .01, ***p < .001. MIDUS = Midlife in the United States Study. Full color version is available within the online issue.

Supplemental Analyses

We tested whether the association between activity diversity and emodiversity was driven by engagement in specific types of activities. Although time spent in certain activities was related to positive or negative emodiversity, activity diversity was still significantly associated with positive or negative emodiversity independently of engagement in specific activities (Supplementary Appendices 1 and 2). Results were consistent in both samples. Note that these results also ruled out potential age-related differences in work status, because we controlled for time spent in paid work.

We also tested the models with other emodiversity metrics as outcomes. Our positive emodiversity measure calculated by Shannon's entropy was highly correlated with those calculated by the Gini coefficient (r = .91 and .92 in M2 and MR, respectively) and the Simpson coefficient (r = .92 and .93, in M2 and MR, respectively). Similarly, our negative emodiversity measure calculated by Shannon's entropy was highly correlated with those calculated by the Gini coefficient (r = .98, in both M2 and MR) and the Simpson coefficient (r = .98, in both M2 and MR). Models using the Gini or Simpson coefficients yielded consistent results for positive and negative emodiversity in both samples (Supplementary Appendix 3).

Discussion

This study integrates two lines of research—the diversity of emotions and the diversity of behaviors—to produce novel findings on how daily emotions and behaviors are related to one another in natural settings. In two independent samples of U.S. adults, greater activity diversity was associated with greater positive emodiversity and greater negative emodiversity. These results are consistent with the theories of emotion suggesting that emotions are generated by the experience of external events (Frijda, 1986; Roseman, 1984; Russell, 2003), and add that the diversity of emotional experiences is related to the diversity of daily activities. Prior research has shown that greater positive emodiversity, and in some cases greater negative emodiversity, is associated with better health and well-being (Grossmann et al., 2019; Ong et al., 2018; Quoidbach et al., 2014; Urban-Wojcik et al., 2020). Another line of research has also shown that greater activity diversity is associated with better health and well-being (Bielak et al., 2019a; Lee et al., 2018, 2020; Urban-Wojcik et al., in press). The current study is the first investigating how these two important concepts for health are interrelated. Importantly, the links were significant for both younger and older adults, but stronger for younger adults in one sample that represent "established adults" in ages 30–45 (Mehta et al., 2020). Below, we discuss the main implications of these findings.

Activity diversity was associated with both greater positive emodiversity and negative emodiversity. Although we did not have the ability to examine causal relationships, our findings are generally consistent with the psychological construction view (Barrett, 2013; Boiger & Mesquita, 2012; Russell, 2003), which suggests that emotions result from the interactions of internal states/knowledge and external events. Our findings are also in line with the perspective that individuals may engage in daily activities that elicit diverse emotions or discover novel lines of behavior to broaden their emotion repertoires. Previous research has primarily focused on the role of positive emotions in broadening people's thought–action repertoires and building personal resources (Fredrickson, 2001). Our findings extend this idea by additionally showing the link between activity diversity and negative emodiversity. That is, participating in diverse daily activities may broaden emotion repertoires in both positive and negative valence which may represent a well-functioning emotional life (Benson et al., 2018; Charles et al., 2017; Grossmann et al., 2019; Magai et al., 2006; Quoidbach et al., 2014, 2018).

Greater activity diversity, which has previously been associated with more beneficial well-being outcomes, was also positively associated with experiencing more diverse negative emotions. The direction of the relationship between negative emodiversity and health and well-being outcomes appears to be more nuanced. In some studies, greater negative emodiversity was related to lower levels of depression and better scores on measures of objective health (e.g., Quoidbach et al., 2014). However, other studies found that more negative emodiversity was related to worse mental and physical health outcomes (e.g., Urban-Wojcik et al., 2020; Werner-Seidler et al., 2020). Furthermore, even within the sample studied by Urban-Wojcik and colleagues (2020), negative emodiversity was still related to better cognitive functioning, while it was related to negative outcomes in other domains. These inconsistencies suggest that greater negative emodiversity may not always be adaptive with respect to all health and well-being outcomes. In addition, there may be contextual moderators that change the relationship between negative emodiversity and health across different domains. More research is needed with respect to this relationship.

It is important to note the role of age in our findings. In our data, age was negatively associated with activity diversity, mostly due to the lack of involvement in paid work and less time with children in older adulthood. Although the association between activity diversity and emodiversity was found after adjusting for age, activity diversity as it is operationalized in this study may not be equally relevant across different age groups. We found a significant age difference for activity diversity and positive emodiversity in one sample (M2), but not in the other (MR). In the M2 sample, the association of activity diversity with positive emodiversity was stronger for younger or established adults than for older adults. The relatively weaker (but still significant) association in older adults may suggest two possibilities. First, it may relate to a true phenomenon of decreased activity diversity with advancing age especially after retirement that is often reported in the literature (Lee et al., 2018; Verbrugge et al., 1996). Second, it may relate to our underestimation of activity diversity in older adults (potentially due to "uncaptured" activity diversity) by using the limited list of daily activities. However, other than the age moderation in the association between activity diversity and positive emodiversity in one sample, we found no other significant age differences. Together, these findings suggest that the association between activity diversity and emodiversity exists across adulthood using our measure. Replication with other measures of activity diversity that use other types of daily activities that are equally relevant across age groups would enhance these findings.

To further increase the validity of our findings, we adjusted for total activity time (total time spent in the seven activities) in all models. We also demonstrated that the association between activity diversity and emodiversity was not driven by engagement in specific types of activities. Interestingly, total activity time was not associated with positive or negative emodiversity in M2 and was negatively associated with positive emodiversity in MR. The negative association in MR was unexpected, but it may mean that more time spent in certain activities relates to experiencing less diverse positive emotions. Indeed, more time spent in either physical or prosocial activities that are known to be related to higher positive affect or more uplifts (e.g., Chi et al., 2021; Sin et al., 2020) were associated with lower positive emodiversity in our study (Supplementary Appendix 2), suggesting that polarized activity engagement may not be good for rich and balanced emotional experiences. Note also that, in M2, participants from the Milwaukee subsample had lower positive and negative emodiversity. This may indicate social disparities in emotional experiences, which calls for more research. Our findings, along with the fact that each of activity diversity and emodiversity has been repeatedly associated with better health in prior research, suggest the utility of these constructs in understanding factors related to health and well-being in adulthood (see Brown & Coyne, 2017; Quoidbach et al., 2018, for their debate on the validity of emodiversity measure).

We did not just focus on variety of daily activities and daily emotions. Our constructs of activity diversity and emodiversity capture both "breadth and evenness" of the experiences based on multiple diary observations (Lee et al., 2018; Urban-Wojcik et al., 2020). Specifically, activity diversity characterizes participating in a variety of activities with relatively even frequency across the activities. Similarly, emodiversity characterizes rich (breadth) and balanced (even) emotional experiences within a single valence (positive or negative). Thus, the association between activity diversity and emodiversity may be due to common variance related to even or balanced daily experiences. Because our results adjusted for potential confounds, such as sociodemographic and health characteristics, total

activity time, and mean positive or negative emotions, however, the link between activity diversity and emodiversity is independent of individual differences in tendency to report more time spent in those activities or higher intensity emotions.

There are several strengths in this study, including harmonization and replication across the two national samples. In particular, our novel research question examining one potential context in which diverse emotions are elicited in daily lives of adults is the major strength of this study. However, there are also limitations in this study. The cross-sectional data of activity diversity and emodiversity prevented us from assessing directionality between the variables. Although our analytic models imply that activity diversity is the predictor of emodiversity, the reversed directionality is also possible. Or, a third variable may be responsible for both emodiversity and activity diversity. Future analyses need to include longitudinal data to determine the direction of the relationship. An experimental design that assigns participants either to a more diverse activity group or a less diverse activity group and then examines emodiversity between the groups may help determine causality. Moreover, there may be "uncaptured" activity diversity that this study missed due to data limitations. Future research may benefit from using a more expansive list of diverse daily activities with specific types within each activity category to reduce potential bias and increase the relevance of the measure across different age groups. Furthermore, the majority of the MIDUS sample were self-identified as White and healthy middle-class adults. Future research needs to replicate the findings among more racially diverse and/or socioeconomically disadvantaged samples. Lastly, given the relationships between activity diversity and emodiversity (both positive and negative) found in this study, future studies could consider their joint associations with health outcomes. Both activity diversity and emodiversity (mostly positive emotions and in some cases negative emotions) are associated with better health and well-being outcomes (Lee et al., 2018, 2020; Ong et al., 2018; Quoidbach et al., 2014; Urban-Wojcik et al., 2020, in press), and thus having both may have synergistic effects on health.

Conclusion

This study contributes to the literature by showing that activity diversity and emodiversity are interrelated across adulthood. Having a broad spectrum of emotions evenly across different types is often associated with a healthy and well-functioning emotional life (particularly among positive emotions); this relates to the diversity of daily activities as found in the current study. Overall, our findings show that engaging in diverse daily activities is related to experiencing diverse emotions in adulthood.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

Conflict of Interest

None declared.

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Author Note

This sample size is slightly larger than what appears in our preregistration. This is due to the addition of data from the Milwaukee subsample of M2 [n = 179], which we included in analyses to utilize all available data. The nature of all effects was consistent with and without the Milwaukee sample. We controlled for the Milwaukee subsample identifier in all analyses using MIDUS II data.

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