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ORIGINAL ARTICLE

Affect Recall Bias: Being Resilient by Distorting Reality

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Abstract

Background According to a growing body of literature, people are quite inaccurate in recalling past affective experiences. Nevertheless, the mechanism underlying this recall bias (i.e., the tendency to overestimate and/or underestimate positive or negative past emotional experiences) remains unclear, and its association with mental health has not been studied yet.

Methods We adopted a smartphone-based Ecological Momentary Assessment to monitor daily affect (n = 92) and investigate the association between affect recall bias, mental health and resilience.

Results While the tendency to overestimate negative affective experiences was observed in participants reporting mild depressive symptoms, positive affect (PA) overestimation as compared to PA underestimation was associated with better mental health (i.e. higher psychological well-being and lower depressive and anxiety symptoms) through the enhancement of resilience. Furthermore, positively biased participants (i.e. PA over estimators) benefited from greater well-being, even when compared to accurate individuals.

Conclusions While people appear to use retrospective PA overestimation as a strategy to enhance well-being and resilience, they are not likely to underestimate past negative experiences to feel better. Accordingly, owning an optimistic vision of the past may represent an adaptive "distortion" of reality that fosters people's mental health. The clinical implications of cultivating PA and learning strategies to regulate both negative and positive emotions are discussed.

Keywords Cognitive bias · Affect recall bias · Ecological momentary assessment · Well-being

Introduction

In recent decades, one of the most studied constructs in the psychological field has been represented by emotion regulation (ER) (Fernández-Álvarez et al. 2018), which refers to the process of down-regulating or up-regulating ongoing emotions in order to achieve desirable states (Gross 1998, 2015). Although the previous literature mainly investigated ER in relation to negative emotions, there is now increasing evidence showing the importance of positive affect (PA) in many aspects of our life (Colombo et al., 2020a, b), and highlighting the importance of cultivating positive emotions (Carl et al. 2013; Diener and Seligman 2002; Lyubomirsky et al. 2005; Tugade and Fredrickson 2007). Accordingly, people adopt up to five different categories of strategies to regulate positive emotions (Gross 2015), which can be implemented either before, during or after the emotion-generation process (Quoidbach et al. 2015). More specifically, the use of strategies to increase PA after the occurrence of an event has been extensively supported, and it is now widely accepted that recalling positive memories is an effective strategy to upregulate positive emotions (Mitchell et al. 1997; Wilson and Ross 2003), enhance emotional well-being, and increase happiness (Bryant et al. 2005; Quoidbach et al. 2010).

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Nonetheless, the emotions experienced during an event do not necessarily match with the emotions prompted by the associated memory: The intense sadness experienced after losing a job, for instance, might be remembered less intensely (i.e. underestimation) or more intensely (i.e. overestimation) sometime later. This phenomenon, called recall bias, has received increasing attention in recent decades because of its correlates with adjustment to life events (Skoronski 2010; Walker and Skowronski 2009). Hedges et al. (1985) first showed that people tend to overestimate experienced levels of PA and negative affect (NA) when asked to retrospectively recall their general mood (i.e., not in relation to a specific event). In recent years, different studies have confirmed this overestimation bias in recalling past affect (Ben-Zeev et al. 2009; Colombo et al. 2019a, b, c; Kardum and Tićac Daskijević 2001; Thomas and Diener 1990; Wirtz et al. 2003), and they have pointed to different factors affecting this mechanism, including beliefs, event reappraisal, contextual information, and personality traits (Levine et al. 2001; Robinson and Clore 2002; Safer et al. 2002). Whereas the tendency to overestimate negatively-valenced emotions has been interpreted as an adaptive evolutionary mechanism to increase the salience of threatening events, which is essential for survival (Miron-Shatz et al. 2009), it is still not clear whether the presence of a bias in recalling positive emotional experiences may play a role for mental health.

According to the Positive Illusion Theory, enhanced self-evaluations, exaggerated perceptions of control, and unrealistic optimism are adaptive mechanisms that improve people's happiness, satisfaction in life, and well-being (Brookings and Serratelli 2007; Taylor and Brown 1988, 1994). Indeed, holding positive illusions is likely to increase the perceived abilities to deal with stressors, thus enhancing motivation and enthusiasm while carrying out actions (Taylor and Gollwitzer 1995). This, in turn, would make it easier to reappraise negative events and implement successful coping strategies (Brown 1993). Likewise, holding an optimistic past-oriented disposition (i.e., overestimating past affective experiences) may represent a sort of strategy to maintain and upregulate positive emotions over time (Bryant 1989), which in turn could increase people's resilience and perceived coping skills: That is, the set of personal qualities that enable an individual to thrive in the face of adversity (Connor and Davidson 2003). The cultivation of positive emotions has been widely found to be an essential coping skill that helps people to deal with daily stressors, with important implications for mental health (Tugade and Fredrickson 2007). Accordingly, the habitual use of savoring strategies has been associated with higher levels of happiness and well-being (Jose et al. 2012; Quoidbach et al. 2010), whereas dampening (i.e. the use of strategies to downregulate positive affective experiences) has been linked to prolonged NA levels (Li et al. 2017; Wood et al. 2003). This could also explain the tendency of depressed patients to retrospectively underestimate PA (Ben-Zeev et al. 2009; Colombo et al. 2019a, b, c), which may arguably reflect the inability of these individuals to recall positive experiences and upregulate positive emotions (Bryant 2003).

Together, there is evidence suggesting that people's past-oriented disposition and, more specifically, the way people recall experienced PA, may in itself be a tool to regulate current emotions. Consequently, the presence of a recall bias may have direct consequences for present affective states and, therefore, individuals' mental health status and well-being. In the present study, we explored the potential effects of PA recall bias (i.e. the tendency to retrospectively overestimate or underestimate positive affective experiences) and NA recall bias (i.e. the tendency to retrospectively overestimate or underestimate negative affective experiences) on mental health outcomes (depressive symptoms, anxiety symptoms, and psychological well-being), and we investigated resilience as a potential mechanism (i.e., mediator) explaining this relationship. To do so, we asked participants to self-report their mood during a two-week Ecological Momentary Assessment (EMA) study, and we subsequently asked them to retrospectively recall the experienced PA and NA levels. We anticipate that PA overestimation will positively contribute to well-being and will be associated with increased resilience. More specifically, we hypothesize PA overestimation to positively impact mental health through the enhancement of an individual's resources to cope with daily stressors. Conversely, and consistently with the previous literature (Miron-Shatz et al. 2009), we expect NA overestimation to be an evolutionary rather than coping mechanism and, therefore, not be associated with well-being.

Methods

Sample

The sample size was calculated considering the correlations as main analyses. Assuming an overall moderate effect size of 0.3, a significance level of 5%, a statistical power of 80%, and a bilateral contrast, the sample size calculation resulted in a sample of n = 82. This study was approved by the ethics committee of Jaume I University (Spain), and informed consent was obtained from all participants.

Data were collected from 97 undergraduate students who were recruited via online advertisements at Jaume I University (Castellon, Spain). In order to exclude possible confounding effects in recalling affective experiences associated with the presence of clinical conditions of depression and/or anxiety, which have been shown to be associated with a negative bias (Wenze et al. 2012), we excluded participants

with a score above 14 on the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al. 2001) and/or the Generalized Anxiety Disorder-7 (GAD-7) (Spitzer et al. 2006), i.e. participants with moderately severe disorders. Accordingly, 5 participants were excluded from the study, thus resulting in a final sample of n = 92. The sample was composed of 69 females (75%) and 23 males (25%). Their mean age was 21.98 years (min = 18, max = 36; SD = 3.41).

Measures

Depressive Symptoms

Participants' depressive symptoms were assessed with the Spanish adaptation of the PHQ-9 (Diez-Quevedo et al. 2001; Kroenke et al. 2001). The PHQ-9 is a 9-item self-report depression screening measure, that has been shown to have good psychometric properties (Wittkampf et al. 2007). A score above 15 indicates moderately severe to severe depression. In our sample, PHQ-9 internal consistency was α = .797.

Anxiety Symptoms

Anxiety symptoms were assessed with the Spanish adaptation of GAD-7 (García-Campayo et al. 2010; Spitzer et al. 2006). The GAD-7 is a quick self-report questionnaire used to identify the presence of minimal, mild, moderate or severe anxiety. This scale has shown good internal consistency and test–retest reliability, as well as convergent, construct, criterion, procedural, and factorial validity (Löwe et al. 2008). In our sample, GAD-7 internal consistency was α = .845.

Retrospective Positive and Negative Affect

Participants were administered the Spanish adaptation (Díaz-García et al. 2020) of the Positive and Negative Affect Schedule (PANAS) (Watson et al. 1988) in order to retrospectively obtain the experienced PA and NA levels during the 2-week EMA study. The PANAS is composed of 10 items to assess PA and 10 items to measure NA. Scores on each scale can range from 10 to 50. The PANAS has been shown to have good construct validity and reliability (Sandín et al. 1999). This scale was administrated at the end of the study and referred to the previous two weeks, i.e. the time during which the daily EMA measures were being collected. In our sample, both PA and NA subscales showed high internal consistency (PA: α = .918; NA: α = .873).

Resilience

Resilience was assessed using the Spanish adaptation (Notario-Pacheco et al. 2011) of the 10-item Connor-Davidson Resilience Scale (CD-RISC-10) (Campbell-Sills and Stein 2007). This scale is composed of 10 statements to be rated on a 5-point Likert agreement scale, which aim at measuring resilience during the last 30 days. Higher total scores indicate greater resilience. The CD-RISC10 has been shown to have good internal consistency (Shin et al. 2018; Singh and Yu 2017). In our sample, the CD-RISC-10 showed high internal consistency (α = .843).

Psychological Well-Being

Psychological well-being was assessed using the Spanish adaptation (Díaz-García et al. 2020) of Ryff's Psychological Well-Being Scale (Ryff 2005; Ryff and Keyes 1995). This scale explores six different constructs of psychological well-being, namely: Autonomy (i.e. an individual's independence from external judgments and social pressures), environmental mastery (i.e. one's ability to take advantage of the environment, opportunities, and activities to achieve personal needs and goals), personal growth (i.e. the sense of continuous self-improvement thanks to life experiences), purpose in life (i.e. the sense of meaning in life, which is defined by clear beliefs, personal values, and aims), positive relations with others (i.e. having satisfactory and trusting relationships, as well as owning an empathetic and warm attitude towards others), and self-acceptance (i.e. a positive attitude toward the current and past self, as well as acceptance of both positive and negative personal qualities). This scale has been shown to have good psychometric properties (van Dierendonck 2004). In our sample, all subscales demonstrated good internal consistency (self-acceptance: = .810; positive relation: α = .840; autonomy: α = .758; environmental mastery: α = .717; personal growth: α = .785; purpose in life: α = .709).

Ecological Momentary Affect (EMA) Measures

Two items about momentary affect were rated on the participant's smartphones using "EMA Móvil", a mobile application that allows to administer ecological assessments via smartphones, and that can easily be monitored and programmed with a web platform (i.e., no programming skills are needed). At each evaluation, participants were asked to complete two 1–5 point Likert scales (1 = not at all; 5 = extremely), one evaluating momentary PA ("To what extent are you experiencing positive emotions at this moment?") and one evaluating NA ("To what extent are you experiencing negative emotions at this moment?").

Procedure

Participants were recruited via poster advertisements placed in different buildings at the university. Students interested

in the study were invited to visit the laboratory to receive more information about the investigation. During this first face-to-face meeting, a researcher administered the PHQ-9 and the GAD-7 in order to verify that the candidates met the inclusion criteria.

Students who met the eligibility criteria were invited to sign the informed consent to participate in the study. Subsequently, each participant was provided with an identification number to download and access the app.

Over the following 14 days, the mobile application "EMA Móvil" prompted three daily assessments of momentary PA and NA. Participants received one random prompt between 9:30 am and 2:00 pm, one between 2:00 pm and 6:30 pm, and one between 6:30 pm and 11:00 pm (semi-random design). To prevent backfilling, participants were given sixty minutes to open the notification on their smartphone and complete the evaluation. After that period of time, the assessment was marked as missing. Participants were provided with an email to contact the researchers if they needed technical support to use the app.

At the end of the study, participants returned to the laboratory and completed the PANAS, Ryff's Psychological Well-Being Scale and the CD-RISC-10. Participants who completed more than 65% of the total EMA assessments received a compensation of 10 euros. Overall compliance (i.e., percentage of completed assessments) was 77.8% (SD = 14.12), and 76 out of 92 participants received the remuneration. Participants who were not remunerated showed compliance rates included between 45 and 65%. No dropouts were observed.

Data Analysis

The mean EMA affect score was obtained by calculating the means of the PA ("experienced PA") and NA item scores ("experienced NA") across the study (42 possible assessments for each participant). To have the same range of scores on the EMA affect measures (each scale has a 1–5 point range) and the PANAS recall measures (each scale originally had a 10-to-50 point range), PANAS recall values were divided by the number of items on the scale (i.e., 10). Thus, the score ranges for both forms of assessment (two weeks of daily, single-item assessments with an app and a single retrospective evaluation using the full-length scale at the end of the study) were the same (1 = lowest affect to 5 = highest affect). In the manuscript, we will use the terms "recalled PA" and "recalled NA" to refer to the PANAS retrospective scores. To explore affect recall bias and distinguish retrospective affect overestimation from underestimation, delta scores between experienced and recalled PA ("PA bias") and between experienced and recalled NA ("NA bias") were calculated (bias = recalled affect—experienced affect). Positive delta scores reflected affect overestimation during the retrospective assessment, whereas negative delta values reflected retrospective affect underestimation.

Kolmogorov–Smirnov test was used to assess normality, suggesting that delta PA ($D(89) = 0.042$, $p = .200$), Ryff's autonomy subscale ($D(89) = 0.072$, $p = .200$) and Ryff's environmental mastery subscale ($D(89) = 0.069$, $p = .200$) were normally distributed. Parametric or non-parametric analyses were adopted, accordingly.

To test the construct validity of the EMA affect items, Spearman correlations between experienced and recalled PA, and between experienced and recalled NA were performed. Furthermore, Generalized Estimating Equations (GEE) (Liang and Zeger 1986) with an unstructured correlation matrix structure and Huber–White standard error estimates were used, which are designed to analyze longitudinal repeated-measures data, and to draw inferences by considering not only variations in affective experience over time within individuals, but also variations in affective experience between individuals. More specifically, PANAS scores were used as predictors of EMA repeated measures.

Experienced and recalled PA and NA scores were compared (Wilcoxon Signed Ranks Test) to test the participants' ability to estimate PA and NA retrospectively. Besides, PA and NA delta scores were compared using a Wilcoxon's Signed Ranks Test.

Correlations analyses were computed between bias scores and mental health outcomes (psychological mental well-being, depression, and anxiety). Linear regressions were also performed to identify PA and NA biases as significant predictors of mental health outcomes.

Mediation models were examined using the PROCESS macro for SPSS (version 23, model 4) which utilizes a bootstrap approach to test the hypothesized indirect effect of the mediators (Hayes 2012). Each analysis utilized 5000 bootstrap re-samples and significance was determined based on 95% bias-corrected confidence intervals. The models tested included PA bias scores (independent variables) and mental health related outcomes (dependent variables) mediated by resilience. We provide estimates of the indirect effects and associated confidence intervals for each mediator.

Finally, A Two-Step Cluster Analysis was performed in order to identify possible subgroupings based on PA and NA biases. Cluster distance was determined using the log-likelihood measure and the number of clusters was determined automatically using Schwarz's Bayesian Criterion (BIC). The average silhouette measure of cohesion and separation was used to indicate overall goodness of fit, and ANOVA analysis was performed to further confirm the significant differences in PA and NA biases scores among the clusters. A multivariate analysis of variance (MANOVA) was conducted to explore differences in mental health related outcomes among the clusters obtained, and Tukey HSD

post-hoc analyses were conducted to explore significant differences.

Results

Affect Recall Bias and Mental Health

Detailed information about the recruited sample and the collected measures is reported in Table 1.

Experienced PA ($M = 2.69$, $SD = .68$) and recalled PA ($M = 2.76$, $SD = .73$) were significantly correlated ($r = .233$, $p < .05$), as well as experienced ($M = 1.51$, $SD = .35$) and recalled NA ($M = 1.92$, $SD = .65$; $r = .532$, $p < .001$). Similarly, the NA-PANAS scores significantly predicted NA-EMA repeated measures ($B = 0.032$, $SD = .005$, 95% CI [.022, .041], $p < .001$), while the PA-PANAS scores significantly predicted PA-EMA repeated assessments ($B = 0.033$, $SD = .008$, 95% CI [.018, .049], $p < .001$).

The comparison of experienced and recalled NA showed a significant mean difference in scores ($Z = -6.13$, $p < .001$), revealing higher NA scores in the retrospective assessments (i.e., NA overestimation during the retrospective evaluation). No significant difference was observed when comparing experienced and recalled PA ($Z = -.68$, $p = .496$). These and the previous findings support the idea that the bias might take different forms (i.e., interindividual order or average scores) depending on the variable of interest (i.e., PA or NA).

Table 1 Frequencies, means, and standard deviations of demographics, compliance and study measures

Demographics	n = 92
Age	22.10 (±3.58)
Sex	69 female / 23 male
Compliance (%)	77.8 (±14.12)
Measures	
Recalled PA	2.76 (±.73)
Recalled NA	1.92 (±.65)
Experienced PA	2.69 (±.68)
Experienced NA	1.51 (±.35)
RYFF'S self-acceptance	26.53 (±5.07)
RYFF'S positive relations	27.69 (±6.03)
RYFF'S autonomy	33.26 (±6.61)
RYFF'S environmental mastery	26.30 (±4.81)
RFF'S personal growth	34.46 50)
RYFF'S purpose in life	27.19 (±4.81)
GAD-7	6.52 (±3.89)
PHQ-9	6.66 (±3.88)
CD-RISC-10	27.53 (±7.11)

PA positive affect, *NA* negative affect; *RYFF'S* Ryff's psychological well-being scale, *GAD-7* generalized anxiety disorder-7, *PHQ-9* patient health questionnaire-9, *CD-RISC-10* Connor-davidson resilience scale-10

Statistically significant differences in rank scores were observed between PA bias ($M = .074$, $SD = .85$) and NA bias scores ($M = .415$, $SD = .55$; $Z = -2.94$, $p < .01$). Specifically, PA bias scores were equally distributed below (i.e., PA retrospective underestimation: $n = 49$, $M = .701$, $SD = .568$) and above 0 (i.e., PA retrospective overestimation: $n = 43$, $M = .641$, $SD = .465$), whereas NA bias scores were more frequently distributed above 0 (i.e., NA retrospective overestimation: $n = 71$, $M = .607$, $SD = .474$; NA retrospective underestimation: $n = 21$, $M = -.235$, $SD = .212$).

PA bias was significantly correlated with the PHQ-9 ($r = -.440$, $p < .001$) and GAD-7 scores ($r = -.411$, $p < .001$), revealing greater PA retrospective overestimation in association with lower depressive and anxiety symptoms (Table 2). Similarly, delta NA was positively correlated with depression ($r = .291$, $p < .001$) but not with anxiety symptoms ($r = .185$, $p = .077$); that is, higher NA retrospective overestimation was associated with more severe depressive symptoms. Together, delta PA ($\beta = -.441$, $SE = .420$, 95% CI [−2.85, −1.18]; $p < .001$) and delta NA ($\beta = 0.203$, $SE = .643$, 95% CI [.138, 2.69]; $p < .05$) significantly predicted PHQ-9 scores, explaining 25% of their variance ($R^2 = .247$; F (2, 89) = 14.59, $p < .001$). Delta PA ($\beta = -0.416$, $SE = .433$, 95% CI [−2.76, −1.04]; $p < .001$) but not delta NA ($\beta = 0.150$, $SE = .663$, 95% CI [−.267, 2.37]; $p = .117$) significantly predicted GAD-7 scores ($R^2 = .203$; F (2, 89) = 11.37, $p < .001$).

Correlation analyses between affect recall bias and mental health outcomes are shown in Table 2. Concerning psychological well-being, delta PA positively correlated with self-acceptance ($r = .432$, $p < .001$), positive relations ($r = .383$, $p < .001$), environmental mastery ($r = .393$, $p < .001$), purpose in life ($r = .241$, $p < .05$), and significantly predicted several well-being outcomes (self-acceptance: $R^2 = .17$; $F(1, 87) = 18.28$; $\beta = 0.417$, $SE = .57$, 95% CI [1.31, 3.58]; $p < .001$; positive relations: $R^2 = .13$; $F(1, 87) = 13.16$; $\beta = 0.362$, $SE = .70$, 95% CI [1.14, 3.91]; $p < .001$; environmental mastery: $R^2 = .16$; $F(1, 87) = 15.9$; $\beta = 0.393$, $SE = .55$, 95% CI [1.97, 3.28]; $p < .001$; purpose in life: $R^2 = .07$; $F(1, 87) = 6.57$; $\beta = 0.265$, $SE = .58$, 95% CI [.332, 2.62]; $p < .05$). Conversely, delta NA only correlated with purpose in life ($r = -.222$, $p < .05$), and it did not predict any of the well-being measures. Overall, these results suggest that overestimating past PA is associated with higher psychological well-being.

Underlying Mechanism of the Relationship Between Affect Recall Bias and Psychological Well-Being

As Table 2 shows, PA bias significantly correlated ($r = .306$, $p < .001$) and predicted resilience ($R^2 = .114$; F

Table 2 Bivariate correlations between PA and NA bias and related mental health outcomes

	1	2	3	4	5	6	7	8	9	10	11
1. NA bias	1.00										
2. PA bias	−.062	1.00									
3. Self-Acceptance	−.093	.432***	1.00								
4. Positive relations	−.022	.383***	.564***	1.00							
5. Autonomy	−.002	.192	.494***	.323**	1.00						
6. Environment mastery	−.117	.393***	.702***	.411***	.423***	1.00					
7. Personal growth	−.093	.118	.301**	.258*	.329**	.465***	1.00				
8. Purpose in life	−.222*	.241*	.748***	.289**	.489***	.738***	.353***	1.00			
9. PHQ-9	.291***	−.440***	−.551***	−.489***	−.334**	−.528***	−.153	−.497***	1.00		
10. GAD-7	.185	−.411***	−.539***	−.474***	−.403*	−.554***	−.177	−.429***	.747***	1.00	
11. CD-RISC-10	−.195	.306***	.683***	.474***	.497***	.599***	.343***	.613***	−.459***	−.544***	1.00

Note that positive bias scores reflect affect overestimation, whereas negative bias scores reflect affect underestimation

PA positive affect, *NA* negative affect, *PHQ-9* patient health questionnaire-9, *GAD-7* generalized anxiety disorder-7, *CD-RISC-10* connor-davidson resilience scale-10

*$p<.05$, **$p<.01$, ***$p<.001$

(2, 87) = 11.18, β = 0.337, *SE* = .830, 95% CI [1.13, 4.43]; $p<.001$), whereas no significant association was observed between NA bias and CD-RISC-10 scores ($r=-.195$, $p=.07$). In other words, people who overestimated past PA, but not those who underestimated past NA, were more resilient. Furthermore, resilience significantly correlated (self-acceptance: $r=.683$, $p<.001$; positive relations: $r=.474$, $p<.001$; autonomy: $r=.497$, $p<.001$; environmental mastery: $r=.599$, $p<.001$; personal growth: $r=.343$, $p<.001$; purpose in life: $r=.613$, $p<.001$) and predicted psychological well-being (self-acceptance: $R^2=.42$; $F(1, 87)=63.73$; $\beta=0.650$, $SE=.06$, 95% CI [.349, .580]; $p<.001$; positive relations: $R^2=.22$; $F(1, 87)=24.45$; $\beta=0.468$, $SE=.08$, 95% CI [.238, .557]; $p<.001$; autonomy: $R^2=.25$; $F(1, 87)=28.67$; $\beta=0.498$, $SE=.09$, 95% CI [.291, .635]; $p<.001$; environmental mastery: $R^2=.33$; $F(1, 87)=42.37$; $\beta=0.572$, $SE=.06$, 95% CI [.269, .505]; p < .001; personal growth: $R^2=.11$; $F(1, 87)=11.14$; $\beta=0.337$, $SE=.06$, 95% CI [.086, .340]; $p<.001$; purpose in life: $R^2=.35$; $F(1, 87)=46.14$; $\beta=0.589$, $SE=.06$, 95% CI [.282, .516]; $p<.001$). As significant correlations were observed between PA bias, CD-RISC-10, and four well-being measures (i.e., self-acceptance, positive relations, environmental mastery, purpose in life), we explored whether resilience significantly mediated the association between PA bias and well-being using the PROCESS macro for SPSS (version 23, model 4), which utilizes a bootstrap approach to test the hypothesized indirect effect of the mediators (Hayes 2012). Significant indirect effects are represented in Fig. 1.

According to the results, a significant indirect effect of PA bias on psychological well-being through resilience was observed: Self-acceptance (unstandardized indirect effect = 1.14, 95% CI [.44, 1.91]), positive relations (unstandardized indirect effect = .92, 95% CI [.34, 1.63]), environmental mastery (unstandardized indirect effect = .093, 95% CI [.38, 1.53]), and purpose in life (unstandardized indirect effect = 1.06, 95% CI [.42, 1.79]). Together, these analyses reveal that resilience partially mediates the effect of PA bias on psychological well-being.

The Combination of PA and NA Recall Biases on Mental Health

A Two-Step Cluster Analysis was conducted to detect potential subgroupings based on PA and NA bias scores (average Silhoutte = 0.5). Four clusters were identified, which showed statistically different PA and NA bias values (PA bias: F (3,88) = 89.03, $p<.001$; NA bias: F (3,88) = 25.31, $p<.001$): (1) The "double bias" cluster (n = 19; PA bias = − 1.06; NA bias = .59) included individuals who retrospectively underestimated PA and tended to overestimate NA; (2) the "negative bias" cluster (n = 30; PA bias = .10; NA bias = .81) included individuals who were quite accurate in retrospectively

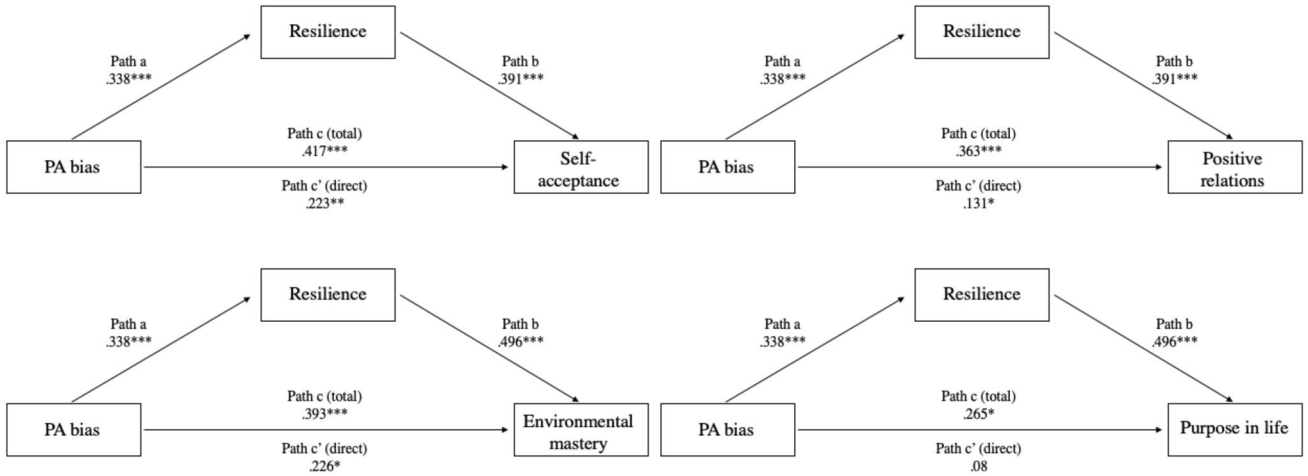

Fig. 1 Standardized regression coefficients for the relationship between PA bias and well-being measures as mediated by resilience

estimating PA, but overestimated NA; (3) the "accurate" cluster (n = 21; PA bias = − .06; NA bias = − .18) included individuals who were quite accurate in retrospectively estimating both PA and NA; (4) the "positive bias" cluster (n = 22; PA bias = 1.14; NA bias = .29) included individuals who were quite accurate in retrospectively estimating NA, but that overestimated PA.

MANOVA analyses were performed to explore differences in mental health measures among the four clusters (Table 3), and a statistically significant effect was observed (Wilks' Lambda = .634, F (24, 226.825) = 1.607, $p < .05$). There were statistically significant differences among the four groups in terms of depressive symptoms (F (3, 93.1) = 7.56, $p < .001$). A Tukey HSD post hoc analysis revealed that the "positive bias" group reported significantly lower depression levels compared to the "double bias" ($p < .001$) and "negative bias" groups ($p < .01$). Significant differences in anxiety scores were also observed among the four groups (F (3, 76.23) = 5.99, $p < .001$). The post hoc analysis indicated that the "positive bias" group reported significantly lower anxiety levels than the "double bias" ($p < .001$) and "negative bias" clusters ($p < .05$). No significant differences were observed between the "double bias" and "negative bias" groups.

Besides, significant differences were observed on self-acceptance (F (3, 167.83) = 8.10, $p < .001$), positive relations (F (3, 107.25) = 3.17, $p < .05$), environmental mastery (F (3, 122.39) = 6.25, $p < .001$) and purpose in life (F (3, 77.14) = 3.63, $p < .05$). More specifically, the "positive bias" cluster reported significantly higher scores than the "double bias" cluster on self-acceptance ($p < .001$), positive relations ($p < .05$), environmental mastery ($p < .001$) and purpose in life ($p < .05$), and higher values on self-acceptance ($p < .05$) and environmental mastery ($p < .05$) when compared to the "negative bias" group. Notably, the "positive bias" cluster also showed higher well-being scores when compared to the "accurate group" on two of the well-being subscales (self-acceptance: $p < .01$; environmental mastery: $p < .01$). Again, no significant differences were observed between the "double bias" and "negative bias" groups.

Discussion

In the present study, we explored affect recall bias by comparing daily to retrospective assessments of affect. Consistent with the previous literature, participants tended to overestimate negative affective experiences. Nevertheless, we did not find the general PA retrospective overestimation that was observed in previous studies (Ben-Zeev et al. 2009; Hedges et al. 1985). Specifically, in our sample, half of the participants were likely to overestimate past PA, but the other half were likely to underestimate it. This divergent result may be due to the novel assessment approach used in the present study (i.e., EMA using a smartphone app) (Colombo et al. 2019a, b, c), but also to the characteristics of the recruited sample, which included mildly depressed/anxious students. In relation to the latter, despite reporting a similar NA overestimation pattern, depressed individuals have been shown to overestimate PA to a lesser extent (Ben-Zeev et al. 2009) or even to underestimate it (Colombo et al. 2019a, b, c). Accordingly, it is possible that the presence of participants with mild symptoms influenced the results observed in this study, increasing the variability of PA bias distribution and leading to an equal number of overestimators and underestimators. This hypothesis cannot be confirmed at this stage and will require further investigation.

An interesting finding in the present study was that PA bias correlated and predicted mental health outcomes. More specifically, PA underestimation was associated with higher

Table 3 MANOVA comparisons of depressive symptoms, anxiety symptoms and psychological well-being in the four clusters

Group	Mean	SD	Tukey HSD comparisons (mean difference)		
			Double bias	Negative bias	Accurate
PHQ-9					
Double bias	9.00	3.68			
Negative bias	7.18	3.23	−1.82		
Accurate	6.35	3.86	−2.65	−.83	
Positive bias	3.91	3.35	−5.09***	−3.27**	−2.44
GAD-7					
Double bias	8.74	3.91			
Negative bias	6.71	3.46	−2.02		
Accurate	6.30	3.86	−2.44	−.41	
Positive bias	4.05	3.35	−4.69***	−2.67*	−2.25
Self-acceptance					
Double bias	23.42	4.64			
Negative bias	26.71	4.71	3.29		
Accurate	25.25	2.76	1.83	−1.46	
Positive bias	30.14	2.64	6.72***	3.42*	4.89**
Positive relations					
Double bias	25.74	5.76			
Negative bias	27.89	5.67	2.16		
Accurate	26.00	7.63	.26	−1.89	
Positive bias	30.64	3.81	4.90*	2.74	4.64
Autonomy					
Double bias	31.00	6.77			
Negative bias	33.07	5.45	2.07		
Accurate	32.95	7.65	1.95	−.12	
Positive bias	35.73	6.43	4.73	2.66	2.78
Environmental mastery					
Double bias	24.11	3.91			
Negative bias	26.04	4.45	1.93		
Accurate	25.10	5.56	.99	−.94	
Positive bias	29.64	3.57	5.53***	3.60*	4.54**
Personal growth					
Double bias	33.89	4.83			
Negative bias	34.21	4.12	.32		
Accurate	34.35	5.85	.46	.14	
Positive bias	35.3	3.77	1.47	1.15	1.01
Purpose in life					
Double bias	25.32	4.53			
Negative bias	26.54	4.96	1.22		
Accurate	27.00	4.92	1.68	.46	
Positive bias	29.82	3.86	4.50*	3.28	2.82

PHQ-9 patient health questionnaire-9, *GAD-7* generalized anxiety disorder-7

*$p < .05$, **$p < .01$, ***$p < .001$

depression and anxiety symptoms, which confirms a recent meta-analysis that pointed out no significant differences in the effect sizes of reduced PA levels in depressed and anxious patients (Khazanov and Ruscio 2016). Additionally, PA overestimation correlated with and predicted higher levels of psychological well-being (self-acceptance, environmental mastery, purpose in life and positive relations), thus supporting the hypothesis that overestimating past positive affective experiences is likely to be an adaptive strategy that positively impacts many dimensions of mental health. Notably, an indirect effect of PA bias on psychological well-being through resilience was observed: In other words, our results suggest that the tendency to overestimate PA does not directly affect mental health, but instead adds up to the set of personal qualities that people use to face adversities (Connor and Davidson 2003) and indirectly enhances mental health. Consistent with the broaden-and-build theory (Fredrickson and Joiner 2002; Tugade and Fredrickson 2007), these results confirm the idea that cultivating positive emotions is a fundamental tool for the enhancement of resilience (Herrero et al. 2019).

Besides, NA bias correlated with and predicted the presence of mild depressive symptoms. Our results are coherent with a long tradition of research showing the presence of a negative bias in depressed patients, which involves increased elaboration of negative information, recall of more negative memories than positive ones, and difficulties in disengaging from negative information (Gaddy and Ingram 2014; Gotlib and Joormann 2010). Accordingly, the tendency to overestimate negative emotional experiences may reflect the negative bias that it is usually reported by depressed people (Craske and Pontillo 2001), and it may be already observable in individuals with mild symptoms. However, the direction of the association between depression and the negative bias remains an open question, and the correlational nature of our results does not allow to disentangle whether the presence of mild depressive symptoms provokes a negative bias or the other way around. Notably, NA bias only barely correlated with one of the Ryff's well-being dimensions and it was not significantly associated with resilience. In addition, almost all the participants in our sample tended to overestimate past NA, and only a few people underestimated it. In other words, NA bias does not seem to have regulatory or coping functions, but it may rather be a "normal" tendency of individuals. Thus, whereas people appear to overestimate past PA to cope with daily stressors, they are not likely to use NA underestimation to feel better and deal with negative events.

In the present study, we also conducted an exploratory cluster analysis to investigate whether the combination of biases could lead to different associations with the outcome measures. Interestingly, participants in the "double bias" cluster (i.e., PA underestimation and NA overestimation) reported the poorest mental health status (in terms of

depression, anxiety and psychological well-being). These scores were clearly worse than participants in the "positive bias" group (i.e., PA overestimation), but also slightly, yet not significantly worse than participants in the "negative bias" group (i.e., NA overestimation, PA accuracy). Although the latter differences were not statistically significant, these results and the marked differences with the "positive bias" group suggest that the concurrent overestimation of NA and underestimation of PA might potentially represent an important vulnerability factor for mental health. Due to the small sample size of each cluster, future studies are needed to confirm this hypothesis, which might open new avenues for research, prevention and treatment purposes. Another interesting finding was that people who tended to overestimate past positive emotions benefited from higher psychological well-being (self-acceptance and environmental mastery), even when compared to individuals who were almost accurate in retrieving their affect ("accurate" cluster). Despite representing a cognitive bias, we therefore suggest that the overestimation of past positive affective experiences can be considered an adaptive distortion of reality.

For many decades, accurate predictions have been considered a marker of mental health: Cognitive distortions or non-accurate representations of reality were considered vulnerability factors for psychopathology (Jahoda 1953). Consistent with the information processing perspective, humans were regarded as scientists gathering and elaborating information from the environment with the aim of building realistic and accurate pictures of the world (Fischhoff 1975). The Positive Illusion Theory offered a divergent perspective, suggesting that cognitive biases are adaptive in many circumstances (Taylor and Brown 1988), and our results are consistent with this latter idea.

According to Taylor and Brown (1988), people are likely to report three positive biases: Unrealistically positive views of the self, exaggerated perceptions of control, and unrealistic optimism. Rather than representing processing errors, these positive biases have been shown to be protective factors for mental health (i.e., useful resources to maintain and promote well-being and happiness). Consistent with this perspective, a growing body of studies has focused on the importance of a future-oriented disposition (Colombo et al. 2020a, b) and, more specifically, the repercussions that future perception has on mental health (Mikus et al. 2017; Weinstein 1980). Accordingly, a new construct called "openness to the future" has been proposed, which refers to the "positive expectations about what life may bring, a sense of competence and ability to cope with events, the anticipation, planning and perseverance to reach an outcome even in the face of adversity, and the acceptance of what cannot be resolved or predicted". Similar to Taylor's positive biases (1988), openness to the future has been shown to be a protective factor for well-being, and it has been associated with higher PA levels, psychological well-being, and self-esteem, as well as with reduced depressive symptoms, anxiety, and worry (Botella et al. 2018). Here, we propose that also people's past-oriented disposition may represent an important protective factor for mental health. Building on our results, we showed that the way we perceive and recall our past experiences is associated with many mental health related dimensions. More specifically, overestimating past affective experiences is likely to be a protective factor associated with greater well-being. Conversely, the tendency to underestimate PA and strongly overestimate NA might potentially represent a risk factor for mental health, although the direction of this association cannot be clarified due to the observational nature of the design.

In relation to the previous, there is evidence suggesting that, while experiencing both positive and negative emotional states is adaptive and essential for survival, dysregulated NA levels along with reduced PA can be associated with the onset of many emotional disorders (Hofmann et al. 2012). From an evolutionary perspective, NA entails the implementation of avoidance or withdrawal behaviors in the face of challenging and dangerous situations, whereas PA fosters approach behaviors and the exploration of novel situations (Cacioppo and Berntson 1999). It is therefore possible to hypothesize that owning distorted emotional representations could affect an individual's behaviors and attitude towards the external world. Accordingly, the concurrent overestimation of NA and underestimation of PA may lead to avoid new experiences and to focus more on negative rather than positive stimuli, which in turn may discourage positive attitudes such as exploration and curiosity.

From a clinical point of view, these results might have some important implications. Reduced PA is indeed a core component of anhedonia, which in turn is a vulnerability factor for mental health. Furthermore, altered levels of both NA and PA has been found to account for the onset and maintenance of many emotional disorders (Brown 2007; Brown and Barlow 2009). However, the primary focus of most of the available interventions has been placed on the reduction of symptoms and on the alleviation of negative emotional states. Considering the growing literature showing the short- and long-terms benefits of PA on health and mental health (Pressman et al. 2018), more efforts should be made in order to create interventions that focus on increasing PA levels and learning strategies to regulate not only negative emotions, but also positive ones. An example in this direction is the Positive Affect Treatment, which focuses specifically on the enhancement of PA. In a recent randomized controlled trial, the authors revealed better clinical outcomes in terms of depression, affect, anxiety, stress, and suicidal ideation in the group of patients receiving Positive Affect Treatment, compared to a Negative Affect Treatment (Craske et al. 2019). Additionally, a possible future line of

research could lie in the self-monitoring of daily affect and ER deployment in relation to positive emotions by means of a smartphone based EMA similar to the one used in the present investigation. Symptom self-monitoring has already been shown to be an efficacious tool to increase awareness and self-empowerment in depressed patients, leading to decreased symptoms and fewer maladaptive behaviors (Simons et al. 2015; Snippe et al. 2016). Consistently, it is possible that monitoring daily affect and related emotion regulation strategies increases people's awareness of experienced positive and negative emotions. Along this line, Sharot (2011) showed that individuals tend to update their predictions when provided with a piece of information that is positive rather than negative (i.e., when the information provides a more optimistic perspective on the prediction made). This updating process appears to produce optimism that is resistant to change. Similarly, providing a feedback about daily experienced emotions may lead habitual PA underestimators to update their predictions to more closely match the real affect experienced, thus reducing the PA bias.

Although this study deepens our knowledge about affect bias and its relationship with mental health, we acknowledge several limitations that could be addressed in future research. An important aspect that needs to be considered is content validity. Although the single items we used to assess PA and NA via EMA significantly correlated with and predicted affect scores, it would be necessary to replicate this finding in a larger population in order to guarantee content validity. In addition, the PANAS consists of 10 items to assess PA and 10 items to evaluate NA. Conversely, we used single items to collect momentary measures of PA and NA because of the daily, repeated nature of the ecological assessments. It is possible that a complex construct like affect might be grasped differently when using 10 items as opposed to one item. While acknowledging this, it is important to note that it would have been too demanding for users to complete the 20 items on the PANAS three times a day for 2 weeks. Similar to other studies (Suso-Ribera et al. 2018), we decided to use single items in order to manage the difficulties in obtaining high adherence rates when dealing with EMA research (Desirée Colombo et al. 2018). Additionally, the indirect effects of recall bias on mental well-being observed in this study should be considered with caution, considering the cross-sectional nature of data (Maxwell and Cole 2007). Further studies are needed to confirm the causal role of PA bias on Ryff's measures through resilience. Finally, further limitations are related to the nature of our sample, which was mainly female and composed of undergraduate students, and that also included individuals with mild depressive symptoms. An important goal for future research would include investigating whether affect recall is affected by sex and whether different patterns can be observed in relation to age. According to the "positivity effect", indeed, old individuals as compared to younger ones are likely to recall more positive than negative information (Carstensen and DeLiema 2018; Reed and Carstensen 2012). It would be therefore important to explore whether the benefits of holding biased representations of past emotional experiences entail the same implications in different populations.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by DC, CS-R and JFÁ. The first draft of the manuscript was written by DC, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript

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Data Availability All data analysed during this study are included in this published article as supplementary information file.

Compliance with Ethical Standards

Conflict of interest Desirée Colombo, Carlos Suso-Ribera, Javier Fernández-Álvarez, Pietro Cipresso, Azucena Garcia-Palacios, Giuseppe Riva and Cristina Botella declares that they have no conflict of interest.

Consent to Publish Patients signed informed consent regarding publishing their data.

Ethical Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Jaume I University (Spain).

Informed Consent Informed consent was obtained from all participants included in the study.

Animal Rights Statements No animal studies were carried out by the authors for this article.

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