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Time evolution of affective processes in a mindfulness-based intervention

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Abstract

Objective: This study aimed at examining the temporal dynamic of the affective trajectories for participants of a self-help mindfulness-based intervention (MBI) compared to a control condition.

Method: This interventional study employed an experience sampling method with two non-randomized groups: a control group ($n = 44$, $M = 37.04$) on the waiting list for the MBI and an experimental group ($n = 45$, $M = 39.90$) practicing mindfulness meditation 20 minutes a day for 42 days. All participants completed an affect self-observation scale twice daily.

Results: Compared to a control condition, the MBI participants' trajectories for activated (ANA) and deactivated (DNA) negative affects revealed an important decrease during the first week. ANA kept decreasing until the end of the MBI whereas DNA showed a slight rise before to decrease again in the last week. Deactivated positive affects increased linearly across the MBI, while activated positive affects slightly decreased.

Conclusion: This study holds promises to consider how a MBI implicates changes in affective life.

Keywords: Mindfulness, Affect, Affective trajectories, experience sampling method

Introduction

Over the past years, the fundamental role of affect has gained in understanding. An important aspect of positive affect (PA) and negative affect (NA) is that they belong to self-perpetuating negative or positive feedback loops (Garland, Geschwind, Peeters, & Wichers, 2015). For instance, people with important NA levels may remain caught in a downward spiral of negativity that propagates emotion dysregulation, whereas PA is thought to create an upward spiral toward more fulfilling positive emotions (Fredrickson, 2004, 2013; Garland et al., 2010).

A study of the dynamic interactions between events and affective experience underlined that PA influenced the trajectory of NA through an *inhibitory coupling effect* by reducing the perceived impact of negative events and by guiding individuals towards recovery (Congard, Dauvier, Antoine, & Gilles, 2011).

As noted by Garland et al. (2015), mindfulness meditation represents experiences and interventions that enhance PA and nurture a positive upward spiral (Fredrickson, 2013). Mindfulness is a skill that can be acquired through a mental training of attentional practice via guided meditation practices. Such practices invite meditators to repeatedly place their non-judgmental and open-minded attention onto the present moment experience (e.g., the breathing or bodily sensations). At the same time, they can notice with curiosity when their mind drifts away and explores other aspects of their experience (e.g., pain, emotion, thoughts). Then, they can gently choose to redirect their attention back to the selected object of their attention (e.g. breathing sensations; Bishop et al., 2004; Kabat-Zinn, 1990, 1994). Mindfulness is perceived as a metacognitive mode of increased awareness and of skilful response to mental processes that contributes to emotion regulation (Bishop et al., 2004; Chambers, Gullone, & Allen, 2009; Garland et al., 2015; Hayes & Feldman, 2004; Hölzel et al., 2011).

Affective processes and mindfulness have been studied for a long time now, and with a growing interest. Dispositional mindfulness was found to be associated with higher levels of

positive affectivity and lower levels of negative affectivity (Brown & Ryan, 2003; Mandal, Arya, & Pandey, 2012). A randomized controlled trial revealed that a community sample participants that took part to a mindfulness-based stress reduction program experienced significant improvements in positive affectivity (Nyklíček & Kuijpers, 2008). Another study compared experience-sampling measures assessed during six days before and after a mindfulness-based cognitive therapy (MBCT, Segal, Williams, & Teasdale, 2002). The authors found that initially distressed participants who completed the MBI displayed higher levels of trait-like PA and lower level of NA at post-assessment compared to waiting list control group participants. Moreover, they noticed that increase (or decrease) in PA at post-test, on a given day, would predict PA increase (or decrease) on the next day (Batink, Peeters, Geschwind, van Os, & Wichers, 2013; Garland et al., 2015). Reviews and meta-analyses of random control trials confirmed that MBIs improved affective outcomes – notably by increasing PA and reducing NA (Creswell, 2017; Goyal et al., 2014; Khoury, Sharma, Rush, & Fournier, 2015).

Whereas an important amount of literature underlined that mindfulness practice tended to promote PA and favoured NA decline (e.g., in a MBCT trial, Garland et al., 2015; for a review and meta-analysis, see Goyal et al., 2014), to our knowledge, very few studies considered the dynamic affective changes as they occur during a clinical trial or in daily life. Snippe, Nyklíček, Schroevers and Bos (2015) used an intensive longitudinal design to study the temporal order of changes in mindfulness and affect dynamics on a daily basis during a MBI. They found that, during a MBI, daily changes in mindfulness grade appeared to precede rather than to follow changes in affect the next day with increase in PA and decrease in NA. More recently, Brockman et al. (2017) examined the link between daily life emotion regulation strategies and every day affective experience. They found that daily mindfulness strategy was associated with lower levels of NA, with a reciprocal influence between the two constructs. Another finding was that mindfulness was associated with higher levels of PA on a daily base.

Although the above-mentioned studies gave some insight to uncover the nature of affective dynamics as they take place in daily life (Gross & John, 2003), the present research intended to go a step further during a MBI (Kuppens, Oravecz, & Tuerlinckx, 2010). Thus, whereas most research on mindfulness effects had predominantly focussed on affective valence (e.g., Brockman et al., 2017; Snippe et al., 2015), the present study not only considered the affect dimension of valence (PA and NA) but also the level of arousal (activated and deactivated affects ; Pettersson, Boker, Watson, Clark, & Tellegen, 2013; Russell, 1980). Examining affective life according to its level of arousal is meant to overcome bias found in previous studies only considering only activated emotions (e.g. excitement, enthusiasm, distress) and therefore missing important information about the participants' affective changes (Mitchell, Stanimirovic, Klein, & Vella-Brodrick, 2009). Moreover, this study aimed at getting a better understanding of a long-standing issue for counselling psychologist and researchers that is to capture the specific and detailed trajectories of change in affect during a MBI, the length of time and amount of mindfulness practice necessary to achieve changes in affect for MBI's participants. As a matter of fact, Carmody and Baer (2009) observed significant effects on psychological distress measures, regardless of the length of mindfulness practice – from 6 to 28 hours. Thus, the present study also intends to innovatively follow the detailed affective trajectories during the course of a MBI.

Therefore, in view of the theoretical models and empirical background presented above, the purpose of the present study was to examine the temporal dynamics of the affective trajectories among a community sample of individuals who had participated in a 42-day self-help MBI or in a waiting list control condition. To our knowledge, this approach had not been explored in the literature so far. An experience sampling method (ESM), known to prevent recall bias and memory distortion (Stone & Shiffman, 2002), was used to provide an unbiased assessment of

daily affective changes during the self-help MBI or in the waiting list control condition. This approach, added with multilevel modelling data analyses, was meant to overcome a static and descriptive approach, and to access the dynamic changes in affect (Keng & Tong, 2016; Snippe et al., 2015). The first hypothesis tested whether individuals practicing mindfulness would experience a gradual decrease in NA trajectories at both activated (ANA; e.g., angry or worried) and deactivated (DNA; e.g., gloomy or sad) levels compared to a control condition. The second hypothesis tested whether the participants to the self-help MBI would experience a gradual increase in their PA trajectories, especially deactivated PA (DPA; e.g., serene or quiet), which are more solicited in this practice than activated PA (APA; e.g., cheerful or excited), compared to a control condition.

Method

Participants

A nonclinical sample of 89 adults aged 20 to 80 years ($M = 38.5$ years old, $SD = 15.1$) participated in the study. Socio-demographic information is available in Table 1. This interventional, nonrandomized study consisted of a control group on a waiting list ($n = 44$) and an experimental group ($n = 45$). Participants were non-remunerated volunteers recruited successively by announcements posted by students from the University of Lille Human and Social Sciences in their social network. The announcements invited people to participate in a 48-day interventional study evaluating the effect a MBI versus a control condition. To be included in the study, participants had to be over 18 years of age. Individuals who reported current mental health treatment or current psychiatric diagnosis were excluded from the study.

Procedure and measures

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Indeed, this study received ethical clearance from the Ethical Research Comity Nord West III's review process. Written informed consent forms were obtained from all individual participants included in the study. Participants were aware that their data would be handled anonymously and that they could quit the protocol whenever they wanted. Participants were allocated to each group according to their preference, although the groups were balanced according to age and sex variables to facilitate proper comparisons. Participants who signed up for the study were mailed detailed instructions: investigators' contact details and questionnaires, as well as the 42-day MBI program for the participants in the experimental group.

The ESM was used for 48 days. Each participant completed a pen and paper self-assessment diary twice a day, between midday and 2 p.m. and then between 7 p.m. and 9 p.m. Participants were invited to gather the self-assessment with a significant moment of their daily routine (e.g., lunch, dinner, or shower) and could set an alarm clock if it helped them remembering to fill the assessment. Days 1-3 allowed participants to become accustomed to the ESM rhythm. Participants completed subscales on affects and other mindlessness propensity variables, such as rumination, which is considered in another study (see Andreotti et al., 2018).

Demographic information. Demographic information was provided on a questionnaire that sought information on each participant's age, sex, family situation, education level and previous mindfulness practice experience.

Adherence. A daily self-observation diary, as part of the ESM, was meant to evaluate the participants' practice adherence with the forthcoming close-ended question: "Have you completed your mindfulness practice yesterday?" with yes/no answers. An adherence score was computed based on it.

Affects. Affects were assessed using 16 adjectives from the Measurement of Affectivity: Valence/Activation (MAVA, Congard, Antoine, Gilles, & Ivanchak, 2005; Congard et al., 2011). Eight of the adjectives represented NA, four represented activated NA (ANA: nervous, angry, irritated, worried), and four represented deactivated NA (DNA: annoyed, bored, gloomy, sad). The other eight adjectives represented PA, four represented activated PA (APA: surprised, cheerful, excited, delighted) and four represented deactivated PA (DPA: serene, calm, quiet, still). The alpha values were acceptable (DNA = .73; ANA = .72; DPA = .74; and APA = .71).

Mindfulness-based intervention

The MBI was created by two trained mindfulness instructors with experience and expertise in delivering mindfulness-based therapy. The program was based on formal mindfulness practices delivered from 20-minute recorded MP3 audio instruction available online or on a CD that participants were invited to use each day, based on the mindfulness-based stress reduction program (Kabat-Zinn, 1990). The 42-day intervention with 14 total hours of formal mindfulness meditation was chosen because significant impacts have been observed when individuals practice 6 to 28 hours of mindfulness meditation (Carmody & Baer, 2009). Audio files were recorded in the studio of the H2C2 platform at Aix-Marseille University (Aix Marseille Univ, CRISIS, Aix-en-Provence, France).

For six weeks, from days 4 to 45, only participants in the experimental group followed the MBI. Participants were invited to find a quiet place where they could practice the daily 20-minute mindfulness exercise using the recorded guidance. Participants received initial information as well as contact details from their investigators. Each piece of guidance reminded the participants to kindly and non-judgmentally bring awareness to their bodily sensations, breath, thoughts and emotions arising during the practice. Participants had specific time windows in which to complete the self-assessment, but they could choose autonomously when to do their mindfulness practice.

The program consisted of six mindfulness guidances repeatedly spread over the six weeks of daily intervention: a body scan (week 1), a breath-awareness mindfulness meditation (week 2), a mindful walking meditation (week 3), a thought-awareness mindfulness meditation (week 4), a sound-awareness mindfulness meditation (week 5) and a loving-kindness meditation (week 6). Participants were invited to follow a printed pre-set schedule indicating the daily mindfulness practice and could contact the investigators if they encountered any difficulty (e.g., technical). Details regarding the guidance used in this MBI are available from the first author upon request and a more detailed description of the intervention is available in Antoine et al. (2018).

Data analyses

The coordinates of the affective trajectories were calculated for APA, DNA, DPA and ANA. and derived time series were used (Boker & Nesselrode, 2002; Pettersson et al., 2013). They were represented by individual averages for the four affective dimensions. They correspond to the derivative 0, the position of the affective state in the time series.

Generalized additive models (GAMs) were used to investigate the evolution of the parameter. GAMs can be understood as extensions of Generalized Linear Models (GLMs) in considering complex nonlinear relations between explicative variables and explained variables. These models are not only descriptive smoothing techniques but also real inferential analyses based on a model selection process (see Wood and Augustin (2002) for a review). The advantage of these models is that the spline function allows nonlinear relations and interactions to be considered. GAMs provide the flexibility needed to describe what are often nonlinear changes in affective states (McKeown & Sneddon, 2014).

GAMs represent a stepwise regression with polynomials. Beginning with multiple regression, in the form of $y = b_0 + b_1x + b_2x^2 + b_3x^3$, a descending stepwise algorithm allows only significant variations in y to be selected, according to the linear, quadratic or cubic function of x . If all three components make an independent, significant contribution, the whole polynomial

function will have four degrees of freedom. These degrees of freedom reflect the complexity of the nonlinear function, which is a combination of a linear trend, a U-shaped function and an S-shaped function. The best method of interpreting the model is to look at the plot of the whole function displayed in graphic form, keeping in mind that if no significant trend is present in the data, the result will be a horizontal line. When comparing changes in two different groups over time, if there is no group difference in the data, the curves will be roughly superimposed. One could seek to precisely determine whether one point in the curve is significantly different from another, as with a post hoc test in an ANOVA, but because the variables are continuous, the number of possible comparisons is infinite. Knowing that the visible variations are significant does not exempt us from taking effect size into account, and it seems reasonable to interpret only trends with meaningful amplitude on the y-axis.

GAMs were estimated from standardized data, which allowed for effect sizes estimation. The models were constrained so that the two experimental groups began the period at identical levels to better consider the temporal evolution of the affective variables.

Technically, the GAMs as implemented in the ‘mgcv’ library in R used spline basis functions, not polynomial functions, and rely on a model selection process that includes a “wiggleness” penalization term to avoid local overfitting (Wood & Augustin, 2002). This procedure aims to select the best model regarding the fit to the data, the parsimony and the smoothness of the retained function.

Additionally, Chi-square and Student’s *t* tests were computed with JASP software version 0.8.2 (JASP Team, 2018) for Windows to compare the group at baseline on the studied variables.

Results

Adherence to the MBI

The mean adherence score in the experimental group was 84.27%, with on average 11.79 hours of mindfulness practiced. A mean of 13.52 assessments (ranging from 0 to 21) were not completed.

Descriptive statistics

Chi-square and independent-samples *t* tests analyses were conducted and the results revealed that the two groups did not differ significantly at baseline according to the socio-demographic variables (see Table 1).

Table 1.

Demographic information for both samples

Variables	Value	Control group (<i>n</i> = 44)	Experimental group (<i>n</i> = 45)	Comparison
Sex	Female (%)	30 (68)	33 (73.3)	$X^2 = .296, ns$
Age	Mean (Range; <i>SD</i>)	37.04 (20-80; 15.1)	39.9 (21-67; 15.2)	$t = .911, ns$
Prior meditation experience	Yes (%)	21 (47.7)	24 (53.3)	$X^2 = .280, ns$
Education level: years after primary school	Mean (Range; <i>SD</i>)	8.3 (0-12; 2.1)	9 (4-15; 2.3)	$t = -1.414, ns$
Activity	Professional (%)	29 (65.9)	28 (62.2)	$X^2 = .673, ns$
	Student (%)	13 (29.5)	13 (28.9)	
	Retired (%)	2 (4.5)	4 (8.9)	
Marital status	Divorced (%)	5 (11.3)	2 (4.4)	$X^2 = 5.127, ns$
	Married (%)	9 (20.4)	15 (33.3)	
	Single (%)	27 (61.3)	26 (57.8)	
	Civil union (%)	2 (4.5)	0	
	Widowed (%)	1 (2.2)	2 (4.4)	

Descriptive statistics and correlations are presented in Table 2.

Table 2.

Descriptive statistics, correlations and estimated GAM parameters for home base affect, affect fluctuations and affective variation speed.

Variables	$M_{CG}(SD)$	$M_{EXP}(SD)$	Control group				Experimental group			
			1	2	3	4	1	2	3	4
Home base										
1. ANA	.81 (.12)	.63 (.17)	1				1			
2. DNA	.81 (.11)	.63 (.10)	.61***	1			.56***	1		
3. DPA	1.87 (.11)	1.91 (.13)	-.41***	-.29**	1		-.65***	-.43***	1	
4. APA	1.29 (.14)	1.19 (.12)	-.12	-.20*	.47***	1	-.02	-.24*	.34***	1

Note. DE = deviance explained (%); *edf* = estimated degrees of freedom; CG = control group, EXP = experimental group.
 *: $p < .05$; **: $p < .01$; ***: $p < .001$

Affective trajectories

The estimated degrees of freedom (*edf*) are available in Table 2. They reflect the complexity of the nonlinear function, which is a composition of a linear trend. Indeed, when the *edf* value equals 1, the relationship is linear. The higher the *edf* value, the more complex the nonlinear aspects are.

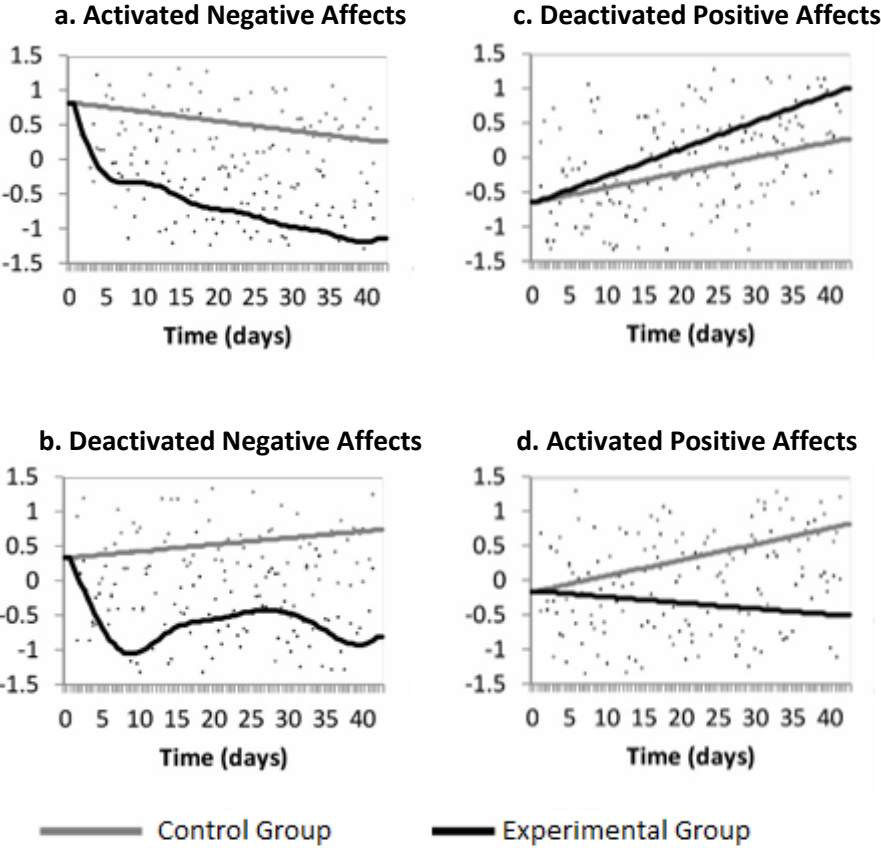
The GAM's results on the influence of the MBI on the affective trajectories compared to a control condition are presented in Figure 1. The MBI participants' ANA (deviance explained = 55.90%) and DNA (deviance explained = 41.20%) trajectories revealed an important decrease during the first week of mindfulness practice compared to a control condition (Figure 1, graphs a & b). ANA kept decreasing until the end of the MBI whereas DNA showed a slight rise from the second to the third week, before to decrease again in the last weeks. People in the control group maintained relatively stable levels of ANA and DNA. Therefore, compared to a control condition, MBI participants seemed to have experienced less nervousness, anger, irritation and worries (i.e., ANA), and less boredom, gloominess and sadness (i.e., DNA).

Regarding PA trajectories, the results differed between APA (deviance explained = 16.60%) and DPA (deviance explained = 23.00%). Whereas DPA trajectory increased linearly (Figure 1, graph c) during the course of the MBI, APA's slightly decreased (Figure 1, graph d; APA's trajectory increased in the control group). Thus, the current study MBI's participants appeared to have experienced more serenity, calm and stillness (i.e., DPA) and seemed to have reduced their experience of cheerfulness, delight and excitement (i.e. APA).

Therefore, at the end of the MBI and compared to a control condition, the coordinates of the home base appeared to have changed for mindfulness meditators with less ANA, DNA and APA and more DPA.

*

Figure 1. Affective trajectories during the course of the self-help MBI



Notes: Each GAM graph shows the longitudinal trajectory of the variable over time (in days). Dots represent each measure per day and per participants to give more precision on variability and individual difference.

Discussion

The present study was meant to gain a better understanding of affective trajectories during a 42-day MBI, by using an ecological momentary assessment and dynamic modeling analyses, compared to a control condition.

Interesting phenomena were identified throughout our efforts to clarify the influence of the MBI on affective trajectories. Individuals who took part to the 42-day MBI reported decreases in ANA and DNA, consistently with the NA reduction found in the literature (Batink et al., 2013; Creswell, 2017; Garland et al., 2015; Goyal et al., 2014; Khoury et al., 2015; Nyklíček & Kuijpers, 2008; Snippe et al., 2015). More subtly, according to the affective activation level, the graphic representations of the dynamic affective trajectories modeling showed several patterns during the 6-week MBI compared to the control condition. The first week trajectories were marked by a rapid decrease in ANA and DPA for participants who practiced mindfulness, compared to control participants. ANA trajectory decreased again until the end of the MBI, while DNA trajectory slightly rose during three weeks before to finally decrease again in the last week.

Regarding PA trajectories, interestingly, the level of DPA rose linearly during the MBI and the level of APA slightly decreased compared to the control group. It does not seem irrelevant to see APA trajectory declined over time as eliciting such affects was not especially encouraged by the intervention. In the meanwhile, DPA trajectory increased over the course of the MBI and such affects may have been more solicited by the mindfulness practice settings itself. Indeed participants were first invited to create a calm and comfortable atmosphere for their daily mindfulness practice. However, this is at odds with Garland et al. (2015) who found increase in PA seeming to include both APA (i.e. happy, enthusiastic, animated) and DPA (i.e. satisfied, inspired), but their intervention was based on a mindfulness-based cognitive therapy (Segal et al., 2002), intending to work also on positive cognition, and assessments encompassed fewer affective items per arousal level. Moreover, although Nyklíček and Kuijpers (2008) found an overall increase in PA after their MBI, affects were not distinguished according to their arousal level in their studies. The present research, by using valence and arousal through a longitudinal approach of affective experience during a MBI appears to offer a novel perspective to approach the unfolding of affective life (Brown & Ryan, 2003). Moreover, the present study allowed noticing that, in this community sample, mindfulness meditators, when compared to a control condition, found the coordinates of their affective home base more elevated for DPA and reduced for ANA, DNA and APA at the end of the MBI.

Garland et al. (2015) had suggested that mindfulness practice participated to emotion regulation and generated therapeutic effects by increasing the proportion of positive-to-negative emotions (Fredrickson, 2013). Whereas NA trajectories did decrease in the present study, one can wonder whether the upward spiral of positive affect (Fredrickson, 2013; Garland et al., 2010) could be differentiated according to the arousal level. Indeed, DPA upward trajectory with affect such as calm and serenity appeared to conduct to more calm and to more serenity during the MBI. Contrarily, APA downward trajectory observed during the MBI did not account for the upward spiral hypothesis (Fredrickson, 2013; Garland et al., 2010).

The present study encompassed several limitations and strengths that must be stated. The non-random group allocation induced a self-selection bias and limited the generality of the outcomes. Additionally, this study lacked of control over the quantity of mindfulness practiced before the trial and of the quality of participants' mindfulness practice during the MBI. Information obtained about the participants' adherence to the MBI is subject to social desirably bias because it was self-reported. Moreover, no information about how distant the mindfulness practices were from the affect evaluation were collected in the intervention group. GAMs modelling of the

affective trajectories according to valence and arousal levels allowed us to follow their course across the 42-day period of time. Thus, this study allowed for a better understanding of the specific trajectories of change in ANA, DNA, APA and DPA in a community sample during a 42-day MBI.

Of course, the present study needs replication before to generalize its conclusions. It would be of interest to expand this study to a clinical population as MBIs have proven effective in this area (Hofmann, Grossman, & Hinton, 2011), particularly in the context of depressive relapse prevention (Strauss, Cavanagh, Oliver, & Pettman, 2014). Additionally, future research may introduce the moderating effects of depression and mindfulness and the mediating effects of affect regulation in the model parameters to allow for a better conceptualization of affect change over time (Harnett, Reid, Loxton, & Lee, 2016; Pepping, Duvenage, Cronin, & Lyons, 2016; Pickard, Caputi, & Grenyer, 2016). GAMs would also help account for changes induced in an intervention based on the characteristics of participants. Analysis of the differential effects of interventions based on initial mindfulness skills, anxiety and personality would be essential to improve the benefits of these practices for all participants (Bhayee et al., 2016).

The graphical representations of affective trajectories suggest different periods. On a clinical perspective, it would be interesting to extend the protocol duration to describe these changes over a longer period and to identify the ideal temporality of future interventions. It would also be interesting to analyze the affective change several months after the end of the MBI to understand more accurately their duration and maintenance as well as the individual changes. A joint study of affects and mindfulness skills should allow for analysis of their interactions (e.g., Snippe et al., 2015).

In conclusion, the combined use of an ecological momentary assessment design and a GAM analysis offers promising prospects for identifying affective trajectories patterns in both general and clinical populations. Notably, it represents an opportunity for analyzing the dynamics of changes induced by practices focused on affective regulation, such as MBIs (Duan, 2016).

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