UNIVERSITY **OF MIAMI**

DEPARTMENT of PSYCHOLOGY



Background

- Emotion is driven by both the valence of a personally relevant outcome and its discrepancy with an individual's expectation – i.e., prediction error (PE; 1).
- PEs and outcomes themselves are implicated in reward processing and as drivers of momentary hedonic well-being in the laboratory (2, 3).
- However, extant studies have not used personally relevant outcomes, nor have they measured both positive affect (PA) and negative affect (NA), or sampled emotion on the time course over which real-world emotion unfolds (i.e., hours to days).
- We used cell phone Ecological Momentary Assessment (EMA; 4, 5) to measure the temporal course of PA and NA in university students who just received grades on midterm exams for which they made predictions (N = 249).
- We divided data into separate exploratory and confirmatory samples and fit a computational model that treats the time course of affect as a convolution of exam grades and PEs.
- Using the model that best fit the exploratory sample (N = 93), we examined the relative impact of exam grade outcomes and PEs on momentary PA and NA in the confirmatory sample (N = 156).

Methods

Procedure

- We recruited undergraduate students from 5 introductory psychology courses (N = 249).
- During each semester we acquired semi-daily assessments of PA and NA using items from the PANAS (6); this comprised participant's baseline data.
- Shortly after each midterm exam, students were prompted via SMS to predict the grade they would receive.
- Following receipt of each exam grade, students enrolled in an 8.25-hour period of dense EMA sampling (one survey every 45 minutes) by clicking a link on the class webpage. Thus, the start time of dense sampling was yoked to the moment students saw their exam grade.
- We collected exam grades from the course professor and calculated exam grade prediction errors for each participant at the end of each semester.

Computational Modeling

- To investigate the relative effects of prediction errors and outcomes on PA and NA, we built separate computational models to predict PA and NA.
- We created continuous, time-decayed predictors of the influence of the prediction errors and grade outcomes on self-reported emotion.
- Decay parameters for the impact of outcomes and PEs on emotion were allowed to vary between PA and NA.
- The decay parameters that minimized RMSE in the exploratory sample (PA = 0.94, NA = 0.96; range = 0.01 -0.99) were used to generate time-decayed, exam-related predictors for confirmatory analyses.











Temporal course of real-world emotion is more strongly linked to prediction error than outcome

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Methods

Figure 1. Semester-long Ecological Momentary Assessment (EMA) design Panel A depicts the 17-week long semester, during which participants completed brief ecological momentary assessment (EMA) self-reports to assess baseline positive affect and negative affect (PA; NA). A set of more frequent EMA samples (a "densesampling period") was yoked to the precise moment when a participant viewed their exam grade (i.e., outcome) for the first time. Dense-sampling periods, which lasted up to 8.25 hours, afforded more fine-grained assessment of the time course of PA and NA in the aftermath of exam outcomes. Panel B depicts baseline EMA self-report surveys, which consisted of 10 items that assessed a broad range of PA and NA. These surveys were distributed to participants once every two days. Momentary PA and NA scores were derived from the mean of PA and NA items from each EMA self-report survey. Panel C depicts the sequence of events following an exam. In the 1-2 hours following an exam, participants were prompted to report the exam grade they expected to receive.

Results

| Li | near M | Mixed Effe | ects Esti | mates | ,) |
|--------------------|-----------------------|--|---|---|------------------------------------|
| $PA_t = \beta_0 +$ | $\beta_1 * \gamma_P$ | a ^{t–j} Outcome | $\beta_j + \beta_2 * \gamma_j$ | PA ^{t-j} PE _j | ; $\gamma_{PA} =$ |
| $NA_t = \beta_0 +$ | $-\beta_1 * \gamma_N$ | _{vA} ^{t–j} Outcome | $e_i + \beta_2 * \gamma$ | ∕ _{NA} ^{t−j} PE _i | ; $\gamma_{NA} =$ |
| Sample | Model | Daramatar | | 05 | |
| | | Farameter | Estimate | SE | p-value |
| | | Outcome | -0.2926 | SE 0.2743 | p-value |
| Evoloratory | PA | Outcome | -0.2926 3.2766 | SE 0.2743 0.6274 | p-value |
| Exploratory | PA | Outcome PE Outcome | -0.2926 3.2766 -0.6595 | SE 0.2743 0.6274 0.4362 | p-value |
| Exploratory | PA | Outcome PE Outcome PE | -0.2926 3.2766 -0.6595 -2.1798 | SE 0.2743 0.6274 0.4362 0.8336 | p-value |
| Exploratory | PA | Outcome PE Outcome PE Outcome Outcome | -0.2926 3.2766 -0.6595 -2.1798 0.2092 | SE 0.2743 0.6274 0.4362 0.8336 0.206 | p-value 0.38 |
| Exploratory | PA NA PA | Outcome PE Outcome PE Outcome PE | Estimate -0.2926 3.2766 -0.6595 -2.1798 0.2092 3.0964 | SE 0.2743 0.6274 0.4362 0.8336 0.206 0.4299 | p-value 0.38 < 0.001 |

Figure 2. Computational models and results

NA

PE

A) Computational models predicting PA and NA from continuous grade outcome and PE predictors. B) Parameter estimates for continuous exam grade outcome and PE predictors for exploratory and confirmatory samples.

Figure 3. Parameter estimates from computational models Exam grade prediction error (PE) positively predicts the time course of PA after receiving an exam grade, and negatively predicts the time course of NA. Exam grade outcome is a significant negative predictor of the time course of NA, but not PA.

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< 0.001

Figure 4. Mean baseline-corrected positive and negative affect (PA; NA) observations from confirmatory participants following exams where participants reported positive and negative exam grade prediction errors (PEs). Panel A depicts the average time courses of PA observations (left) and NA observations (right) following exams in which participants outperformed their predictions (i.e., positive prediction errors). Panel B plots the average time courses of PA observations (left) and NA observations (right) following exams in which participants' grades fell short of their predictions (i.e., negative prediction errors). Error ribbons for each line represent the standard error of the mean.

Results





- event.







Discussion

Conclusions

• Unexpected, personally relevant outcomes are associated with measurable changes in the time course of individuals' affective responses.

• The effect of PE on PA diminishes to one half of its initial magnitude within 6–6.5 hours of a personally meaningful

• Larger decay rates for NA (0.96) suggest that the effect of PEs on NA tend to persist longer, as a PE of equal magnitude reaches half of its initial magnitude within 8–8.5 hours; notably longer than PA.

• While PEs may exert a larger-magnitude effect on PA compared with NA, the impact of personally meaningful events and PEs on PA may be more fleeting than on NA.

Implications

• Decay rate estimates suggest that real-world human lasts on the scale of hours (or longer) and not seconds, and the drivers of affect on the timescale of seconds to minutes and minutes to hours might be similar.

• These findings are indicative of differences in drivers of momentary PA and NA reactivity after a meaningful event. • Affective science must continue to incorporate measures of expectation to appropriately model emotion.

Future Directions

• Future iterations of this paradigm will incorporate a richer set of predictors, such as counterfactual alternatives, to better understand how contextual and event-related factors drive emotion dynamics.

• Future work should compare different scaling functions (i.e., nonlinear) for real-world outcomes to better understand the nature of their impact on the time course of affect.

• EMA, as well as computational approaches, may provide utility in clinical settings, allowing for better prediction of risk for depressive moods in the context of acute stressors, low outcomes, and negative PEs.

Publication Information

• Please see our publication in Journal of Experimental Psychology: General, Temporal dynamics of real-world emotion are more strongly linked to prediction error than outcome (7): https://qrco.de/villano_etal_2020_jepgen



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