Using Experience Sampling to Investigate Affect at Encoding and Episodic Memory

Adelaide McKenzie (adelaidem@student.unimelb.edu.au)
Hyungwook Yim (hyungwook.yim@unimelb.edu.au)
Ben Stone (benjamin.stone@gmail.com)
Simon J. Dennis (simon.dennis@unimelb.edu.au)

School of Psychological Sciences, The University of Melbourne, Australia

Abstract

Intensive longitudinal data was collected through the concurrent use of a passive experience sampling (ES) smartphone application collecting objective measures of experience, and an ecological momentary assessment (EMA) app collecting self-reported affect. After a week-long retention interval, participants completed a memory test generated from paired ES and EMA data. Participants were asked to select the GPS location at the time of a paired target event from four alternatives. Correct retrieval was not predicted by self-reports grouped by negative valence/high arousal or negative valence/low arousal. Positive valence/high arousal reported at encoding predicted greater probability of incorrect responses. Conversely, positive valence/low arousal predicted greater probability of correct identification of target. At retrieval, choice was predicted by dissimilarities in discrete emotions between target and distractors, suggesting the use of affect as a contextual mechanism.

Keywords: episodic memory, affect, emotion, experience sampling, ecological momentary assessment

The relationship between emotion at encoding and episodic memory is one that feels intuitive. While evidence quantifying interactions between emotion at encoding and enhancements at retrieval is vast and fragmented, what remains clear is that affect, a term used to encompass both mood and discrete emotion, plays a key role during encoding, shaping memory for episodic detail at retrieval. To date, there is no evidence of this relationship using an experience sampling (ES) paradigm. Through the combined use of passive and active ES measures, this study sought to provide naturalistic quantifications of the ways in which affect at encoding influences accuracy for contextual detail, and additionally aimed to investigate the degree to which affect acts as a contextual feature of episodic memory at retrieval.

Flashbulb memory is a key area of research that adopts a naturalistic approach in quantifying enhancements in episodic memory. A flashbulb memory is an episodic memory for a surprising and often public event (Brown & Kulik, 1977). Episodic enhancements have been primarily demonstrated for flashbulb events associated with highly arousing negative affect (Day & Ross, 2014; Gandolphe & Haj, 2017). There is some flashbulb research that has worked to determine an association between typical flashbulb memory patterns and positive affect (Levine & Bluck, 2004), however in research comparing both positive and negative reactions to the same flashbulb event, negative affect (NA) has been shown to be associated with greater consistency and event-related detail than positive affect (PA; Kensinger & Schacter, 2006).

The majority of findings in this field, however, are drawn from a test/retest paradigm where the baseline memory is captured as soon as possible after the flashbulb event. As highlighted by Hirst et al. (2015), this latency prevents researchers from obtaining objective measures for accuracy, and as a result the flashbulb memory literature tests for consistency in memory over time, rather than accuracy. Lanciano et al. (2010) therefore highlight the need to replicate flashbulb-like effects in controlled laboratory settings to allow for greater detail in the quantification of an emotional episodic memory enhancement.

Source memory laboratory studies focusing on an affect enhancement for episodic detail provide an opportunity to explore similar effects to flashbulb memory in paradigms that offer objective measurements for accuracy. Support for enhancement effects in source memory research is mixed - there is evidence of both source memory enhancements (e.g. Schmidt, Patnaik, & Kensinger, 2018) and deficits (e.g. Bisby & Burgess, 2013) for items associated with NA and PA. The role of arousal is equally mixed - source enhancements for episodic detail have been shown when paired with arousing, negatively valenced items (e.g. Schmidt et al., 2011), however source deficits have been demonstrated for both highly arousing negatively valenced items (e.g. Mao, You, Li, & Guo, 2015) and arousing, positively valenced items (e.g. Wang, 2015).

Given this discrepancy between episodic impairment and enhancement, source memory research has therefore not been able to replicate and better quantify ecologically valid flashbulb findings. This may be due to the confines inherent to a laboratory setting. Kensinger (2009) questions the quality and applicability of the affective experience in episodic memory research drawn from laboratory-based behavioural studies. Current smartphone technologies provide opportunities to address the methodological concerns of flashbulb memory research without compromising the validity of affective experience.

While affect at encoding may exert influence on accuracy at retrieval, it seems interesting to also consider *how* this influence is exerted – is it simply a by-product of increased attention and sensory processing at encoding, or does affect at encoding contribute to the contextual representations used to isolate and scaffold episodic memory for specific events. Ekstrom and Raganath (2018) suggest that while spatial and temporal cues are privileged in episodic retrieval, other features relevant to context at encoding may be incorporated into the spatiotemporal scaffolds of an event, and may therefore similarly act as a feature of memory at retrieval. Like space and time, differences in affective states between events may assist in isolating a specific event, meaning retrieval of an event with an associated affective context may be easily confused with other events that have a similar emotional profile.

Bower's (1981) associative network theory of emotion provides a potential framework when determining the role of affect at encoding as an episodic cue at retrieval. This theory posits that affect coexists with other categorical knowledge and schemata, and the retrieval of an event with an associated affective profile may automatically activate retrieval of other similarly valenced events (Bower, 1981). Bower's (1981) associative network theory is evident in mood congruency effects, where affective states at retrieval increase the likelihood of emotionally related stimulus being recalled (Sheldon & Donahue, 2017). As suggested by the associative network theory of emotion, memory could therefore be organised according to affective experience, and like spatial and temporal information, retrieval of an event may generate retrieval of events with a similar affective profile. Additionally, in laboratory-based free recall tasks, retrieved stimuli have been shown to cluster according to valence (Long, Danoff, & Kahana, 2015; Talmi & Moscovitch, 2004). If affective experience assists in the categorisation and organisation of memory, this would suggest that differences in emotional contexts may help discriminate between episodic events at retrieval. Long et al. (2015) claim that such evidence demonstrates contextual mechanisms similar to spatiotemporal scaffolds in episodic memory. Given evidence in support of the network theory of emotion, it may be plausible that the influence of affect at encoding on memory is twofold – it improves encoding of the event, thereby increasing the probability of correct retrieval, and contributes to the memory trace at retrieval by providing contextual representations.

The present study aims to first quantify enhancement effects of affect at encoding in a design that addresses the methodological issues from both flashbulb and source memory research. Using a combination of ecological momentary assessment (EMA) to provide self-reports of emotion in real-time and passive sensor data to capture objective measures of experience, this study aims to use participant-generated data to provide greater nuance to the role of affect grouped according to valence and arousal on episodic memory by testing accuracy for episodic detail at retrieval. The episodic detail tested was identification of a participant's location at a specific time drawn from GPS coordinates. Further, this study sought to determine the degree to which affective states at encoding are used as categorical retrieval cues to provide further nuance to affect enhancement effects. Given evidence substantiating Bower's (1981) network theory of emotion, it was expected that choice of provided options will be predicted by dissimilarities in self-reported discrete emotions between provided target and distractors.

Method

Sixty-seven participants (40 female, 26 male, 1 other) were recruited using flyers, online bulletins, and through the student research pool of a major university. The sample was aged between 18 and 45 years (M = 25.85, SD = 6.61). Participants were required to be over the age of 18, own and use an Android smartphone, and needed regular access to WiFi.

Measures

Affect Surveys Participants were prompted to download SEMA3 (Koval et al., 2019), an EMA application designed to deliver surveys on smartphones in real time. Each survey consisted of a block of current state affect self-report ('How [happy; excited; confident; bored; content; angry; anxious; sad; irritable; relaxed] do you feel right now?'). Responses were indicated on a sliding scale from 0 ('not at all;) to 100 ('very much'), with the initial value starting on 50. The order of self-reports was randomised for each survey.

Sensor Data Participants downloaded the Unforgettable.me application onto their Android smartphone. Unforgettable.me is a life-logging app that works in the background collecting sensor and network data (Dennis, Yim, Garrett, Sreekumar, & Stone, 2019). Once downloaded, the app collected accelerometry continuously, and global positioning system (GPS) coordinates and obfuscated audio every 10 minutes. GPS was collected via access to device GPS/location services. The Unforgettable.me app generated obfuscated audio by transforming raw audio frequencies using Mel-Frequency Cepstral Coefficients (MFCC) to remove temporal components. Depending on the participant's systems hardware, accelerometry was sampled between 8 and 15 hertz.

Figure 1: Large all-stop button on the Unforgettable.me app to allow participants pause data collection.

To assist in mitigating privacy concerns, participants were able to pause data collection (see Figure 1) and review and remove any data they were unwilling to share on both the unforgettable.me app and on the Unforgettable.me website once uploaded (see Figure 2).

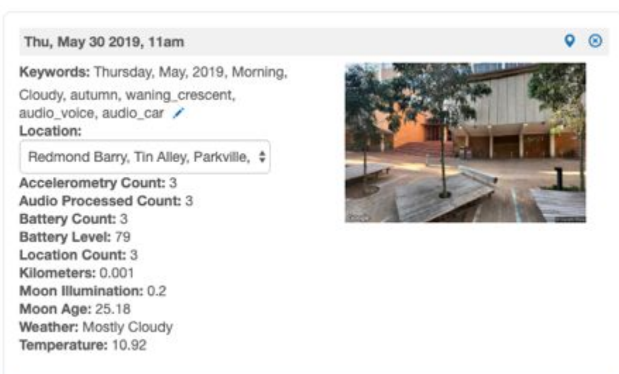

Figure 2: Uploaded Unforgettable.me app data to the Unforgettable.me server. Participants are able to search uploaded data and delete data using the "x" button in the top right hand corner.

Procedure And Design

Participants used both apps concurrently for 14 days. Participants received affect surveys through phone notifications eight times each day (112 in total) between 8:30 and 21:30 using stratified random sampling. Participants had a window of 20 minutes to complete a survey before it expired to prevent backfilling. Compliance ranged from 56% to 100% (*M* = 88.52, *SD* = 12.41).

After a seven day retention interval post data collection, participants were prompted to complete a memory test on the Unforgettable.me marketplace. The Unforgettable.me marketplace is an online platform where participants grant a specific study access to their collected data (Dennis et al., 2019).

Once participants consented for access to their data, each trial was dynamically created by pairing each SEMA3 event to the closest unforgettable.me data point within 60 minutes of the SEMA3 event start time ($M_{seconds}$ = 221.62, *SD* = 334.53). Each paired SEMA3 and unforgettable.me event was a target in a trial, and distractors were randomly selected from paired SEMA3/unforgettable.me events greater than 100m (*M*= 99178.19, *Mdn* = 2615.22, *SD* = 1062412.44, *min* = 100.11, *max* = 16186027.19) away from target paired event based on the participant's GPS data.

Participants were then provided with instructions and completed two practice trials prior to the main experiment. In each trial, participants were asked to select their location at a specific time on a GoogleMap interface by choosing one of four drop-pins generated from one target paired event and three distractor paired events.

Figure 3: Example of memory test trial. The minimum distance between target and distractors was 100m. The time cue is drawn from the start time of a SEMA3 survey.

The number of trials for each participant varied based on compliance and on the amount of SEMA3 and Unforgettable.me events able to be paired. The minimum number of trials was 11 and the maximum was 114[1] (*M* = 78.06, *SD* = 19.03).

Results

Scores from all measures were standardised prior to analysis. Data was analysed in Private (Dennis, 2019), a privacy analysis platform purpose-built to analyse experience sampling data that blinds researchers to raw participant data.

[1] One participant was sent 125 surveys and completed 114 due to technical issues.

Descriptive Statistics

Accuracy on the memory test ranged from 35% to 95% correct target identification (M = 0.67, SD = 0.15).

When grouped according to arousal, density plots for summed reported ratings for negative valence/high arousal (“Angry”, “Anxious”, “Irritable”) and negative valence/low arousal (“Bored”, “Disappointed”, “Sad”) demonstrated low variability in self-reported ratings, with an evident skew towards reporting lower levels for both NA groupings (see Figure 4).

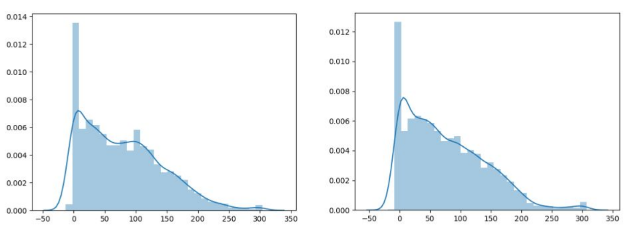

Figure 4: Distribution of summed ratings for negative valence/high arousal (left) and negative valence/low arousal (right)

There was no evidence of significant skew in the distance plots for positive valence/high arousal (“Happy”, “Excited”, “Confident”) and positive valence/low arousal (“Relaxed”, “Content”), suggesting variability in PA experience (see Figure 5).

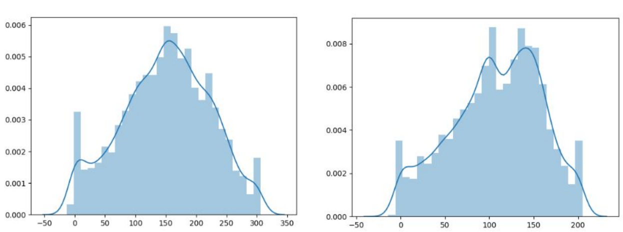

Figure 5: Distribution of summed ratings for positive valence/high arousal (left), positive valence/low arousal (right).

Predictive effect of affect on accuracy

A multinomial logistic regression was used to model the probability of accuracy at retrieval as predicted by self-reported affect at encoding. Affect was represented by four predictor variables generated by the summed reported intensity ratings of discrete emotions grouped according to valence and arousal. Accuracy was categorically defined as correct (or incorrect) identification of location at retrieval.

In order to examine the magnitude and precision of the posterior probability distributions, β medians and 95% Credible Intervals (CI) were calculated to illustrate posterior distributions of probability. Evidence of an effect was inferred if zero was not within the 95% credible interval of the parameter.

Gelman-Rubin diagnostics (Gelman & Rubin, 1992) were computed to evaluate Hamiltonian Markov Chain Monte Carlo (MCMC) convergence. In comparing estimated between-chain and within-chain variance of the two MCMC chains generated, the calculated upper estimate for the potential scale reduction factor (PSRF) was found to be <1.1 (Gelman & Rubin, 1992) for the intercept ($\widehat{R}$ = 0.99), negative/high arousal ($\widehat{R}$ = 0.99), negative/low arousal ($\widehat{R}$ = 0.99), positive/high arousal ($\widehat{R}$ = 0.99), and positive/low arousal ($\widehat{R}$ = 0.99). Given this evidence to suggest chain convergence, it can be assumed that estimates were sampled from the posterior of the distribution.

Negative affect did not have a significant effect on accuracy. Positive high arousal emotions decreased accuracy, while positive low arousal emotions increased accuracy (see Figure 6).

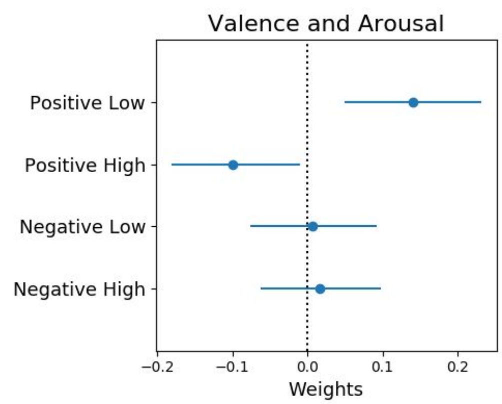

Figure 6: Prediction accuracy by valence and arousal. Dots indicate beta means and bars indicate 95% credible intervals.

Predictive effect of affect on choice

A conditional logistic regression (McFadden, 1973) was used to model the degree to which distances between affective states at encoding predicted choice at retrieval. The interpretation of the results from a conditional logistic regression is slightly different to a logistic regression model. In the above logistic regression model, the correct/incorrect responses will be used as dependent variables (DV) and be predicted by the independent variables (IV) which are properties of the stimulus itself. However, a conditional logistic regression model uses the chosen/not-chosen options on each trial as DVs, and the IVs are characteristics of these options (i.e., distance of the choice to the correct answer), which varies trial by trial.

Therefore, in the current study, if the coefficients of the conditional logistic regression is negative, it indicates that participants tend to choose options that have smaller distance to the correct answer (e.g., options that are spatially closer to the correct answer, or options where self-reported emotions are closer to the correct answer) and vice versa.

Passive measures – GPS, accelerometry, and obfuscated audio - were analysed to facilitate comparison between passive and active experience sampling measures.

There were 14 predictor variables generated from distances between target and distractor events – spatial distance; audio distance; accelerometry distance; and distances between each discrete emotion self-report. Spatial distance, accelerometry distance and audio distance were calculated using Euclidean distance. Distances between each discrete emotion were calculated using the absolute difference between reported scores.

Variables were analysed in independent conditional logit models.

Gelman-Rubin diagnostics suggested convergence of chains for each independent model given the calculated upper PSRF estimates were found to be <1.1 (Gelman & Rubin, 1992) for audio ($\widehat{R}$ = 1), accelerometry ($\widehat{R}$ = 1.004), GPS ($\widehat{R}$ = 1.008), “Angry” ($\widehat{R}$ = 1), “Anxious” ($\widehat{R}$ = 1), “Irritable” ($\widehat{R}$ = 1), “Bored” (= 1.001), “Disappointed” ($\widehat{R}$ = 1.001), “Sad” ($\widehat{R}$ = 1), “Happy” ($\widehat{R}$ = 1), “Excited” ($\widehat{R}$ = 1), “Confident” ($\widehat{R}$ = 1), “Relaxed” ($\widehat{R}$ = 1), and “Content” ($\widehat{R}$ = 1.001). It was therefore assumed that estimates were sampled from the posterior of the distribution.

Figure 7 shows the mean beta weights along with their 95% credible intervals for each self-reported discrete emotion. When modelled independently, discrete emotion distances between target and distractors each predicted the probability of choice.

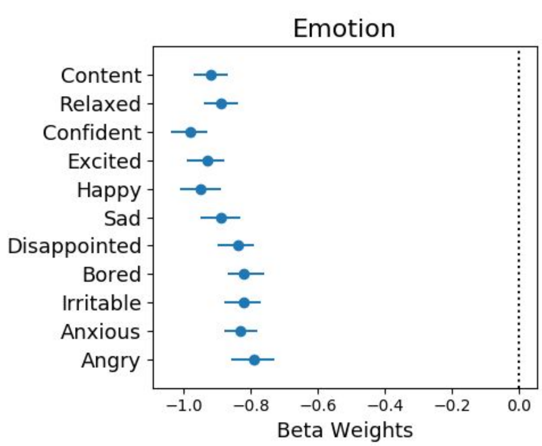

Figure 7: Choice as predicted by distances between each discrete emotion when modelled independently.

Independent models of passive measures drawn from sensor data indicated that spatial distance, β = -36.62 [-40.22, -33.20], audio dissimilarity, β = -0.25 [-0.31, -0.19], and accelerometry dissimilarity, β = -0.82 [-0.90, -0.74] between target and distractors predicted the probability of choice at retrieval given that the 95% CI did not capture zero. Spatial distance was the largest predictor of choice.

Discussion

The present study utilised passive and active experience sampling measures to investigate the ways in which affect at encoding informs episodic memory at retrieval in an intensive longitudinal design.

This work is the first to use an ecologically valid paradigm that offered objective measures of accuracy. There was no evidence to support the hypothesised role of NA (both negative valence/high arousal and negative valence/low arousal) in predicting accuracy for location identification at retrieval. Self-reported affective states typified by positive valence/high arousal at encoding predicted a decrease in accuracy. Conversely, self-reported positive valence/low arousal at encoding was found to predict accuracy at retrieval.

This study was also the first to use an experience sampling design to explore the degree to which affective states at encoding act as a feature of episodic memory at retrieval through an analysis of choice at retrieval. The results suggested that choice of location was predicted by distances between affective states.

When drawing conclusions from neural evidence, Bowen, Kark, and Kensinger (2018) assert the privileged status of NA compared to PA in episodic memory given negative events have been shown to trigger increased encoding of sensory detail. The results of this study, however, found no such benefit for location identification for either NA groupings - there was no evidence to support enhancements or deficits in retrieval of contextual detail in an experience sampling paradigm.

Discrepancies between previous naturalistic and laboratory-based literature and the current findings may be explained by low variability of reported levels of NA compared to PA. Participants did not frequently report experiencing the discrete emotions used to capture negative valence/high arousal and negative valence/low arousal. Such results indicate that NA was not experienced as frequently as PA over the two-week data collection period. This finding is supported by previous smartphone ecological momentary assessment research – in a year-long study, participants (N = 11,572) were 2.5 times more likely to report PA than NA (Trampe, Quoidbach, & Taquet, 2015). A longer data collection period may therefore be needed in future work to capture more varied experiences of NA in order to provide greater variability when determining effects.

The current findings do suggest a potential role of self-reported PA at encoding in accuracy for location identification at re. The present work aligns with evidence suggesting episodic enhancements for positive valence/low arousal (Pierce & Kensinger, 2011) and impairments for contextual encoding for positive valence/high arousal (Mao et al., 2015; Wang, 2015). This dissociation between PA groupings according to arousal illustrates its potential role in PA when encoding episodic detail. Positive valence/high arousal self-reports at encoding predicted deficits in accuracy location identification at retrieval. Self-reported positive valence/low arousal, however, enhanced the predictive probability of target identification. PA states with low levels of arousal may therefore promote a more flexible encoding of the environment, allowing for an episodic enhancement to be realised at retrieval.

This study offered evidence of the use of affective experience at encoding as a feature of episodic memory. Recent experience sampling research using similar paradigms to the current study have demonstrated that choice is predicted by temporal and spatial distance (Yim, Ong, Stone, & Dennis, 2019). The results of this study further these findings – when modelled independently, choice was largely predicted by spatial distances, but also by dissimilarities between self-reported discrete emotions. Like time and space, this suggests that affective experiences at encoding may work as contextual mechanisms when retrieving episodic details such as location.

Such findings substantiate the associative network theory of emotion (Bower, 1981). The results highlight two potential retrieval mechanisms at play – either the correct target was identified as predicted by dissimilarities in affect between target and distractors, or a distractor was chosen as predicted by similarities in affective state to the target event. The first mechanism indicates that, as posited by Bower (1981), affect may work as a cue at retrieval to differentiate between memory traces, consistent with similar laboratory-based findings (Talmi & Moscovitch, 2004). The second mechanism potentially implies spreading activation at retrieval as suggested by associative network theory (Bower, 1981), where memory for an event promotes retrieval of memories with similar emotional content, thereby causing confusion when choosing between target and distractor events. Prior evidence of this associative network has used mood congruency effects to substantiate this theory, where emotional cues have been shown to facilitate retrieval of autobiographical memories with a similar affective profile (Sheldon & Donahue, 2017). The present study provides evidence to extend these findings even in the absence of an explicit emotional cue, offering ecological validation of similar effects previously demonstrated in a laboratory-based free recall study where in absence of mood congruency, emotional items were shown to cluster at recall (Long et al., 2015). It is relevant to note, however, that the models used to analyse choice included identification of correct target events. Given participants were more likely to choose the correct option, this may be pivotal in driving this effect. If so, only inferences regarding dissimilarities between target and distractor events predicting choice could be drawn. To provide more conclusive evidence to support spreading activation of affect, future analyses focusing on incorrect responses may better quantify the degree to which affect similarities between target and distractor events predicted distractor choice at retrieval.

Limitations and Conclusion

Inferences suggesting a role of arousal within PA in predicting accuracy for contextual detail at retrieval assume that the episodic cues used at retrieval in this study (location and time) were not central to affective experiences which may be unlikely in practice. A consideration of this in future work may more meaningfully determine the degree to which subjective reports of the centrality of tested episodic detail to the affective experience at encoding mediate accuracy for location identification at retrieval.

An inherent limitation to the use of distances between self-reports to predict choice is that receiving and completing an ecological momentary assessment survey could operate as a feature of memory, making it difficult to dissociate the use of an ecological momentary assessment event to capture experiences from the affective experience captured by ecological momentary assessment. This limitation is seemingly unavoidable to this design, however future investigations comparing subjective and objective experience sampling measures of emotion to determine validity of objective sensor data in capturing emotion could be highly valuable to empirical work seeking to mitigate this issue.

The present research provides naturalistic nuance to episodic effects driven by affective experience at encoding, suggesting a role of arousal within PA in predicting accuracy for contextual detail at retrieval. The current study additionally lends support for an associative network theory of emotion, suggesting that affective states at encoding may work similarly to spatial cues when retrieving and isolating a specific event. The relationship between emotion at encoding and subsequent episodic memory is one that is complex but is intuitively understood. The unique experience sampling design used to investigate these effects offers new pathways for further explorations into this dynamic relationship between affect and episodic memory.

References

Bisby, J. A., & Burgess, N. (2013). Negative affect impairs associative memory but not item memory. *Learning & Memory, 21*, 21–27.

Bowen, H. J., Kark, S. M., & Kensinger, E. A. (2018). NEVER forget: Negative emotional valence enhances recapitulation. *Psychonomic Bulletin & Review, 25*(3), 870–891.

Bower, G. H. (1981). Mood and memory. *American Psychologist, 36*(2), 129–148.

Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, *5*(1), 73–99.

Day, M. V., & Ross, M. (2014). Predicting confidence in flashbulb memories. *Memory, 22*(3), 232–243.

Dennis, S. J. (2019, July 30). The design of Private: A privacy preserving probabilistic language [Blog post]. Retrieved from https://simondennis.blog/2019/07/30/the-design-of-private-a-privacy-preserving-probabilistic-language/

Dennis, S. J, Yim, H., Garrett, P., Sreekumar V. & Stone, B. (2019). A system for collecting active and passive experience sampling data. *Behavior Research Methods, 51*(4), 1839–1848.

Ekstrom, A. D., & Ranganath, C. (2018). Space, time, and episodic memory: The hippocampus is all over the cognitive map. *Hippocampus*, *28*(9), 680–687.

Gandolphe, M-C. & El Haj, M. (2017). Flashbulb memories of the Paris attacks. *Scandinavian Journal of Psychology, 58*, 199–204.

Gelman, A., & Rubin, D. B. (1992). Inference from iterative simulation using multiple sequences. *Statistical Science*, *7*(4), 457–472.

Hirst, W., Phelps, E. A., Meksin, R., Vaidya, C. J., Johnson, M. K., Mitchell, K. J., … Olsson, A. (2015). A ten-year follow-up of a study of memory for the attack of September 11, 2001: Flashbulb memories and memories for flashbulb events. *Journal of Experimental Psychology: General, 144*(3), 604–623.

Kensinger, E. A. (2009). Remembering the details: Effects of emotion. *Emotional Review, 1*(2), 99–113.

Kensinger, E. A., & Schacter, D. L. (2006). When the Red Sox shocked the Yankees: Comparing negative and positive memories. *Psychonomic Bulletin & Review*, *13*(5), 757–763.

Koval, P., Hinton, J., Dozo, N., Gleeson, J., Alvarez, M., Harrison, A., Vu, D., Susanto, R., Jayaputera, G., & Sinnott, R. (2019). SEMA3: Smartphone Ecological Momentary Assessment, Version 3. [Computer software]. Retrieved from http://www.sema3.com

Lanciano, T., & Curci, A., Semin, G.R. (2010). The emotional and reconstructive determinants of emotional memories: An experimental approach to flashbulb memory investigation. *Memory, 18*(5), 473–485.

Levine, L. J., & Bluck, S. (2004). Painting with broad strokes: Happiness and the malleability of event memory. *Cognition and Emotion, 18*(4), 559–574.

Long, N. M., Danoff, M. S., & Kahana, M. J. (2015). Recall dynamics reveal the retrieval of emotional content. *Psychonomic Bulletin & Review, 22*(5), 1328–1333.

Mao, X., You, Y., Li, W., and Guo, C. (2015). Emotion impairs extrinsic source memory-An ERP study. *Biological Psychology, 110,* 182–189.

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science*, *6*(2), 114–133.

McFadden, D. (1973). Conditional logit analysis of qualitative behaviour choice. In P. Zarembka (Ed.), *Frontiers in Econometrics* (pp. 105–135). New York: Wiley.

Pierce, B. H., & Kensinger, E. A. (2011). Effects of emotion on associative recognition: Valence and retention interval matter. *Emotion, 11*(1), 139–144.

Schmidt, K., Patnaik, P., & Kensinger, E. A. (2011). Emotion's influence on memory for spatial and temporal context. *Cognition and Emotion, 25*(2), 229–243.

Sheldon, S., & Donahue, J. (2017). More than a feeling: Emotional cues impact the access and experience of autobiographical memories. *Memory & Cognition, 45*(5), 731–744.

Steinmetz, K. R., Knight, A. G., & Kensinger, E. A. (2016). Neutral details associated with emotional events are encoded: Evidence from a cued recall paradigm. *Cognition and Emotion*, *30*(7), 1352–1360.

Talmi, D., & Moscovitch, M. (2004). Can semantic relatedness explain the enhancement of memory for emotional words? *Memory and Cognition, 32*, 742–751.

Trampe, D., Quoidbach, J., & Taquet, M. (2015). Emotions in everyday life. *PloS One*, *10*(12), 1–15. doi:10.1371/journal.pone.0145450

Wang, B. (2015). Positive arousal enhances the consolidation of item memory. *Swiss Journal of Psychology, 74*, 91–104.

Yim, H., Ong, B.W. R., Stone, B., & Dennis, S. J. (2019). Understanding human memory for where using experience sampling data. In A. Goel, C. Seifert, & C. Freksa (Eds.), *Proceedings of the 41st Annual Conference of the Cognitive Science Society* (pp. 3390). Austin, TX: Cognitive Science Society.