Language and event recall in memory for time

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Introduction

We remember and talk about events as unfolding over time. When recalling a recent past event, we are often able to recollect its duration and mentally reproduce its component actions, as if replaying the event in our mind. However, key aspects of duration memory are poorly understood, in particular, how event memories map onto clock time and how this mapping is modulated by language. Indeed, we do not perceive and remember objective clock time, unless we pay attention to clocks. Instead, we build event representations that are not replicas of our experiences but are rather temporally compressed, and thus do not often coincide with the real time it took these experiences to unfold.

Here, we investigate the relationship between time, memory and language by examining how people recall and mentally reproduce (replay) events that were conceptualized through language. We specifically ask two main questions. First, what determines the duration and clock accuracy of event reproductions from memory. Second, how these reproductions are modulated by linguistic descriptions, thus potentially leading to distorted reproductions.

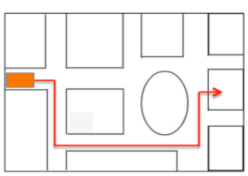

Figure 1: Stimulus example. The arrow indicates path.

In four studies, participants were first asked to study cartoon-like animations accompanied by descriptive phrases for a later memory test. The animations varied in duration from 3-9s and showed geometric figures moving in a familiar setting. Each animation was paired with one of two possible descriptions implying either fast or slow-motion speed, for example, *grandma taking the bus to the hospital* vs *an ambulance taking someone to the hospital* (cf. Fig. 1). Thus, the two phrases implied a shorter or longer event duration. The descriptions provided critical information to understand the animation, which would otherwise be unspecific as to the nature of the moving object. After learning, participants were asked to replay the animations in their minds *exactly as they occurred in their original time course* when prompted with either an animation frame or the corresponding description. Participants clicked the mouse at the start and finish of their mental replays. The reproduced or replayed duration was measured. Finally, they were asked to verbally recall as many details as they could about each animation when prompted.

We hypothesized following Ornstein (1969) recall-based account that the amount of information recalled would explain duration memory over and above the influence of stimulus duration and number of stimulus segments (Faber & Gennari, 2017). Importantly, when the amount of exposure to the same stimuli increases (as in Exps. 2 & 4), we expected that more event information should be learned, and thus, the reproduced duration should lengthen particularly for the stimuli where reproduction accuracy could be improved. Under this hypothesis, memory biases previously reported (Roy & Christenfeld, 2008), such as the tendency to shorten long events and lengthened short ones should emerge from the information recalled: people remember proportionally more information per time unit for short events, leading to lengthened duration reproductions, whereas they remember proportionally less information per time unit for long events, leading to shortened reproductions.

Additionally, we hypothesized following interactive-encoding accounts (Lupyan, 2008; Feist & Gentner, 2007) that if verbal encoding distorts the initially encoded memory, events described with slow-phrases should be mentally reproduced as longer than those described with fast-phrases, even when a visual-cue prompts event replay. Alternatively, retrieval-based accounts (Alba & Hasher,1983) argue that language should only play a role at retrieval, i.e., the effect of descriptions should be observed only when descriptions prompt replays.

Experiments 1 & 2: visually-cued event replays after one and three stimulus viewings

Participants learned 21 animations alongside descriptions either once in random order (exp. 1) or three times (3 runs through the stimuli in random order, exp. 2). Mental replay and verbal recall were cued by a visual frame. Separate pre-tests determined stimulus characteristics (implied motion speed, familiarity, number of segments, etc.).

Results indicated no influence of language on duration reproductions. However, the event information recalled (as measured by the number of words used in verbal recall) modulated reproduced duration. As the number of words recalled increased, so did the reproduced duration, over and above the influence of stimulus duration and the number of stimulus segments. Moreover, the extent to which reproduced duration deviated from the clock stimulus duration (deviation index = reproduced duration/stimulus duration) were lengthened for shorter animations but were shortened for longer animations, as previously reported (Fig. 2). A deviation index of 1 indicates accurate reproductions, with smaller or larger indices indicating under- or over-reproductions. Moreover, more accurate reproductions (closer to 1) were obtained in Exp. 2 compared to Exp. 1, particularly for longer animations, where more details could be learned with more exposure. This suggests that the number of details recalled underpins duration reproductions. Critically, the density of the details recalled (the number of words recalled per seconds in an animation) explained deviation indices. Thus, shorter animations were reproduced as longer because more details were proportionally recalled for them compared to longer animations, thus providing a possible explanation for the temporal bias observed.

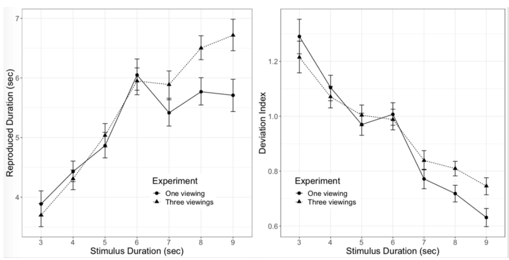

Figure 2: Reproduced duration and deviation index as a function of the stimulus duration

Experiment 3 & 4: verbally cued event replays after one or three stimulus viewings

These studies used the linguistic descriptions to prompt event replays and verbal recall, instead of a visual cue. Note that language may influence reproductions because participants are unsure of what they saw after a single viewing. Thus, testing deeper learning may reveal whether weak memory traces play a role in language effects.

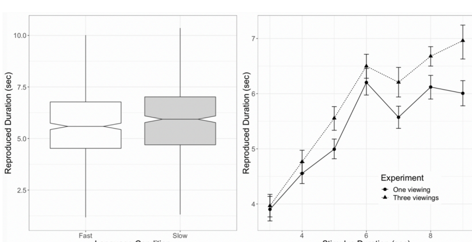

Figure 3: Reproduced duration as a function of language condition and stimulus duration in Exp. 4

Results indicated that for one and three stimulus viewings, there was a language effect. Slow-phrases led to longer reproductions whereas fast phrases led to shorter ones across all stimulus durations. This suggests that the memory representation retrieved is combined with top-down conceptual information present at retrieval, leading to a biased reproduction. In addition, the density of the information recalled predicted deviation indices (temporal bias), replicating exps. 1 & 2. Thus, both language and event recall influenced replays, leading to linguistically and temporally distorted retrieval.

Discussion

We investigated how event reproductions from memory were modulated by event descriptions and the event information recalled. Visually cued event reproductions did not vary as a function of language, suggesting that language did not modulate the way the animations were encoded or subsequently retrieved. Instead, event memory was the main source of information guiding duration reproductions, as evidenced by the predictive role of the number of words used in recall, over and above stimulus duration and segments. Critically, irrespective of cue type, better learning led to longer event reproductions for animations where accuracy could be improved, consistent with the recall-based view.

Verbally-cued reproductions led to shorter or longer reproductions according to the phrases, even after extensive learning. The concurrent influence of recalled information and language, therefore, suggests that the retrieved episodic event representations were combined with linguistic concepts, leading to hybrid event reproductions modulated by both event memory and language.

In all experiments, shorter stimuli were lengthened, and longer stimuli shortened, despite modulations by learning and language. The deviation index in all studies was explained by the information density recalled (the number of words recalled per second). We argue that information density and temporal biases stems from event perception and encoding mechanisms: Information at event boundaries is recalled better than within-event information (Zacks et al., 2007). In longer events, which tend to have longer segments, more within-segment information is forgotten, whereas for short events, which have relatively short segments, more information is proportionally retrieved.

Taken together, these results are consistent with both a recall-based view of memory for duration and a retrieval account of the role of language in memory.

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