Consciousness and Cognition 21 (2012) 953–960

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Short Communication

Integrating unseen events over time

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ARTICLE INFO

Article history:
Received 5 June 2011
Available online 17 March 2012

Keywords:
Unconscious
Implicit
Nondeclarative
Subliminal
Episodic memory
Associations
Relational
Inference
Flexibility
Compositionality

ABSTRACT

Events often share elements that guide us to integrate knowledge from these events. Integration allows us to make inferences that affect reactions to new events. Integrating events and making inferences are thought to depend on consciousness. We show that even unconsciously experienced events, that share elements, are integrated and influence reactions to new events. An unconscious event consisted of the subliminal presentation of two unrelated words. Half of subliminal word pairs shared one word ('winter **red**', '**red** computer'). Overlapping word pairs were presented between 6 s and 78 s apart. The test for integration required participants to judge the semantic distance between suprathreshold words ('winter computer'). Evidence of integration was provided by faster reactions to suprathreshold words that were indirectly related versus unrelated. This effect was independent of the time interval between overlapping word pairs. We conclude that consciousness is no requirement for the integration of discontiguous events.

1. Introduction

In everyday life, we experience contiguous and discontiguous events that share elements. Our ability to detect common elements in separate events and to use these elements to mentally bridge events and integrate knowledge from events is owed to episodic memory. The term episodic memory refers to the conscious recollection of personally experienced episodes (Squire, 2004; Tulving, 2002). Episodic memories are typically formed incidentally and rapidly because no life event is identical to another. Episodic memories consist of the elements of an event and their associations. Because the elements and their associations are stored independently, they can be reactivated separately and through many routes. This feature refers to the representational flexibility of episodic memories (Cohen & Eichenbaum, 1993; Moses & Ryan, 2006). A flexible memory representation permits the inferential use of memories in new situations: Based on the integration of knowledge from past events, we make inferences that guide our interpretation of new events. E.g., having met Paul at a party last week, where I learned that he works for Google in Zurich, and having met Tim today who was wearing a Google T-shirt, I am not surprised to see Paul and Tim days later sitting together in an airplane leaving from Zurich. The common element 'Google' in these two events links Tim with Paul in my episodic memory and leads me to think that the two persons might be working for the same company.

In the present study, we investigated whether discontiguous events would be integrated in long-term memory, even if these events are not experienced consciously, but unconsciously, due to their subliminal (invisible) presentation mode. We reduced the complexity of an event to the visual presentation of two unrelated words, such as 'winter red'. These word pairs were subliminal because they appeared very briefly, preceded and followed by pattern-masks. Half of the subliminal word pairs shared one element, e.g., 'winter **red**' and '**red** computer', and were therefore overlapping (experimental condition). The other half of subliminal word pairs was not overlapping because these word pairs shared no elements,

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doi:10.1016/j.concog.2012.02.013

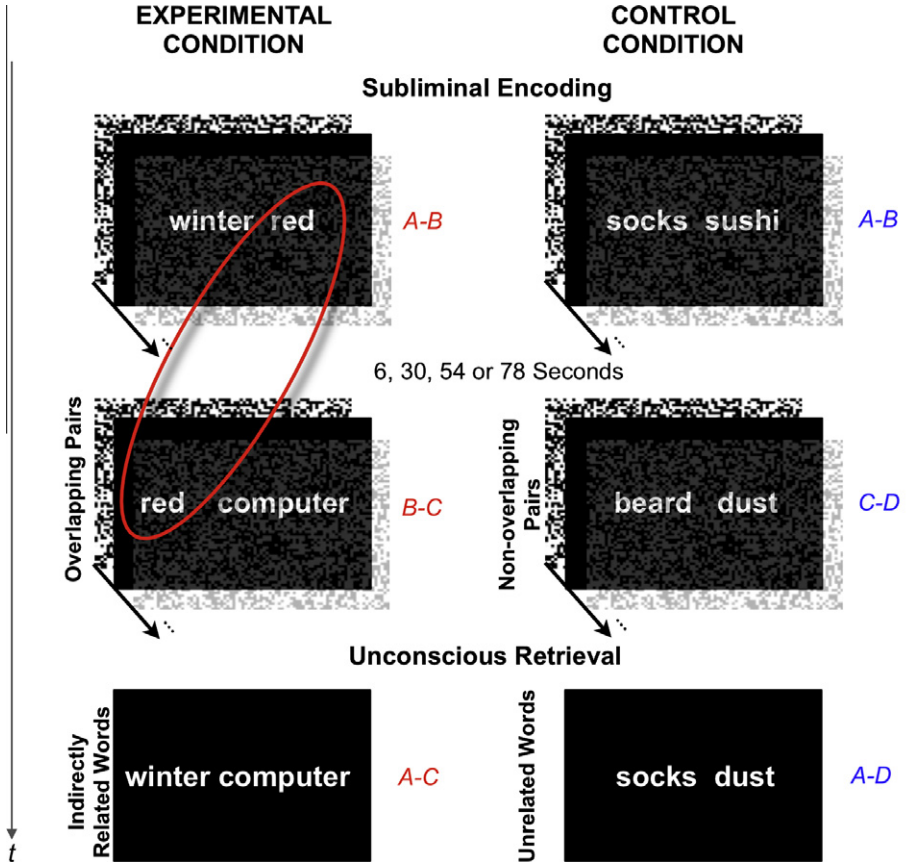

Fig. 1. Experimental design. For unconscious encoding, we presented subliminal word pairs that shared one word (A–B, B–C; experimental condition) or not (A–B, C–D; control condition). The time interval between corresponding subliminal word pairs was 6 s, 30 s, 54 s, or 78 s. The black-and-white pixel images represent the pattern-masks that were presented preceding and following a word pair. For the test of unconscious inference, we used visible presentations of word pairs that contained words, which were either indirectly related (A–C; experimental condition) or unrelated (A–D; control condition). The test of unconscious inference required participants to judge the semantic distance between words of a test pair.

e.g., 'socks **sushi**' and '**beard** dust' (control condition) (see Fig. 1). Corresponding word pairs were presented 6 s, 30 s, 54 s, or 78 s apart from each other. This time interval was filled with other word pairs. We hypothesized that participants would form unconscious associations between words in the initially presented pair ('winter **red**') and in the later presented pair ('**red** computer'). We further expected the repetition of the subliminal word '**red**' in the later presented pair to trigger the unconscious reactivation of the initially presented word pair. The mental co-activation of both pairs might then allow for their integration and the inference that 'winter' is related to 'computer' through '**red**'. The following test for integration required participants to judge the semantic distance (near versus far) between two words that were presented suprathreshold for conscious inspection. The two words were either indirectly related through two subliminal events that shared one word, like 'winter computer', which were related through '**red**' (experimental condition), or unrelated but previously presented, like 'socks dust' (control condition) (Fig. 1). The mental integration of overlapping subliminal events was expected to accelerate participants' semantic judgments of indirectly related compared to unrelated words.

This study replicates and extends previous work that demonstrated the feasibility of one-trial paired-associative encoding and long-term retention of subliminal face-word pairs (Degonda et al., 2005; Duss, Oggier, Reber, & Henke, 2011; Henke, Mondadori et al., 2003; Henke, Treyer et al., 2003) and word–word pairs (Reber & Henke, 2011). These previous studies demonstrated the feasibility of forming new associations between subliminal items presented at one point in time. Building on this evidence, the current experiment tested for the unconscious integration of subliminal information that was presented during two (and not just one) subliminal events.

2. Method

2.1. Stimuli and task structure

The words used in the main experiment were 192 German nouns. The mean number of characters per word was 6.51 (*SD* = 2.24), and their mean logarithm of frequency of use was 2.567 (*SD* = 0.932). A further set of 60 words was used for