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Influences of context load and sensibleness of background photographs on local environmental context-dependent recognition

Takeo Isarida[a,*], Toshiko K. Isarida[a], Takayuki Kubota[a], Miyoko Higuma[a], Yuki Matsuda[b]

[a] School of Management, Shizuoka Sangyo University, Ohara, Iwata 438-0043, Japan
[b] Faculty of Informatics, Shizuoka University, Johoku, Hamamatsu 432-811, Japan

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ABSTRACT

The present study explored which theory can best explain local environmental context-dependent recognition. One type of theory (encoding specificity principle) posits that recognition reflects remembering of the past episode, whereas the other theory (ICE: Item Context Ensemble) posits that recognition reflects familiarity-based judgements. In three experiments, a total of 120 undergraduates intentionally studied a list of unrelated words superimposed on background photographs. Half of the photographs contained a specific area where words are typically presented (sensible photographs), and the other half contained no such area (insensible photographs). Context loads were 24, 20, and 4 for Experiments 1, 2, and 3, respectively. After a filled 5-min retention interval, participants received a recognition test. The old words and the same number of new words were randomly presented at test one at a time, and participants were required to respond whether each word was old or new. In the same-context condition, words were presented at test on the same photograph as at study, whereas in the different-context condition, a new background photograph was presented at test. Context-dependent recognition discrimination was found only with the sensible photographs but not with insensible ones in Experiments 1 and 2, whereas both sensible and insensible photographs showed significant context-dependent recognition discrimination in Experiment 3. Experiments 1 and 2 showed the concordant effects, but no effect in the false alarm rate was found in Experiment 3. The present results imply that there are remembering- based and familiarity-based production mechanisms for local environmental context-dependent recognition. The context load may mediate the shift from one to the other.

Introduction

Environmental context-dependent memory refers to incidental environmental information, in which focal information is processed, which enhances memory performance for the focal information (Isarida & Isarida, 2014; Smith, 1988). Environmental context-dependent effects in recall provide evidence supporting the encoding specificity principle (Tulving & Thomson, 1973), whereas the effects in recognition have not been so clearly identified. This is because the evidence for environmental context-dependent recognition of meaningful materials in particular is ambiguous (Isarida, Isarida, & Sakai, 2012). Although Smith and Vela's (2001) meta-analysis reported that the size of context-dependent recognition was nearly the same as for free recall, Isarida et al. (2012) demonstrated that the effect size for recognition in the meta-analysis was a mix of large effect sizes for unfamiliar or meaningless materials (e.g., Dalton, 1993; Krafka & Penrod, 1985; Malpass & Devine, 1981; Smith & Vela, 1992) and small or no effect sizes for meaningful materials.

Contexts can be classified in terms of associative generality based on the rate of change. One type of context can associate with all the elements of an event, because it typically remains stable or changes very slowly during the event; this is called global context (Glenberg, 1979). The other type can associate with a limited number of elements of an event, because it changes relatively quickly; this is called local context (Glenberg, 1979). This global/local distinction was once seen as similar to that between environmental and semantic contexts. That is, global context was nearly equivalent to environmental context, and local context was nearly equivalent to semantic context. However, it has recently been found that a certain type of environmental context functions as local context (Isarida & Isarida, 2007; Rutherford, 2004; Smith & Vela, 2001) rather than as global context. The local environmental contexts mostly consist of digitally represented environments on the computer screen, such as background color (e.g., Isarida & Isarida, 2007; Rutherford, 2004), simple visual context (a unique combination of foreground color, background color, and location on a computer screen, e.g., Murnane & Phelps, 1993, 1994, 1995), rich visual context

* Corresponding author.
E-mail address: isarida@ssu.ac.jp (T. Isarida).

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(background picture or photograph, e.g., Hockley, 2008; Murnane, Phelps, & Malmberg, 1999) and video context (video clips consisting of motion pictures with sound, e.g., Smith & Handy, 2014; Smith & Manzano, 2010).

Under local environmental contexts, the items may be separately associated with the corresponding computer information in a one to one fashion. Isarida and Isarida (2007) found that the background-color context must change screen by screen to produce the context-dependent effect in free recall, because five or more successive presentations of the same background color eliminated the background-color dependent memory. Furthermore, they found that the items presented one at a time against the same background color did not cluster with each other in free recall. Sakai, Isarida, and Isarida (2010) simultaneously presented 6 items per screen, and found that recalled items were clustered by screens but not by background colors. These findings imply that each item was associated not with one common color but with the respective screen on which the item was presented. Thus, no global episodic-memory trace may be encoded with the same color and the items, but rather the items may be encoded in a one to one fashion with the corresponding screens on which the items were presented. As such, the other visual contexts, such as background photograph or picture contexts, could be also classified as local contexts.

The present study explored which theory can best explain local environmental context-dependent recognition, especially for background-photograph contexts. There are two types of theories of context-dependent recognition. One type assumes that recognition judgments reflect remembering of the past episode, so that the mechanisms of both recall and recognition are fundamentally the same, as stated by the encoding specificity principle (Tulving & Thomson, 1973). In contrast, the other type assumes that recognition judgments reflect not the remembering of the past but memory-strength- or familiarity-based judgements (e.g., Anderson & Bower, 1972; Kintsch, 1970). This type was developed into various global matching theories assuming that recognition judgments reflect matching all the information available in probe at test and in memory (see Clark & Gronlund, 1996). Furthermore, the ICE (Item-Context-Ensemble) theory successfully incorporated the functions of the incidental environmental contexts (Murnane et al., 1999).

The explanations of context-dependent recognition processes by remembering of the past episode are slightly different for global and local environmental contexts. Global environmental contexts, such as place, odor, and background music, are found to be best explained by the outshining account, consisting of the encoding specificity and the outshining principles (Isarida et al., 2012, 2018). More specifically, when a recognition test is conducted under an old context, the context will facilitate retrieval of the learning episode in which participants learned a list of old items. First, if an item cue (a copy of the target item) is weaker than the context cue, then a positive context-dependent effect in recognition discrimination will appear. Second, if an item cue is stronger than the context cue, then the item cue suppresses (outshines) the function of the context cue, as posited by the outshining principle (Smith, 1988, 1994). Consequently, the context will do nothing for the retrieval of the learning episode, so that no context dependent effect will appear in the hit rate, false alarm rate, or recognition discrimination.

This prediction was empirically confirmed with place, odor, and background-music contexts (Isarida et al., 2012, 2018). Isarida et al. (2012) found that place-dependent recognition was not found with long study times for words but was found both with short study times for words and nonwords. Additionally, when a positive context-dependent effect in recognition discrimination appeared, a positive context-dependent effect on the hit rate and a reversal of the effect on the false alarm rate appeared. This is called a mirror effect (Glanzer & Adams, 1985). Isarida et al. (2018) found nearly the same results with odor and background-music contexts. Furthermore, Isarida et al. (2018) found that the effect size (Cohen's *d*, Cohen, 1992) for place, odor, and background-music dependent recognition is inversely proportional to the strength of item cues. The item-cue strength was estimated by the hit rate in the DC condition (Isarida et al., 2018).

In the case of local context, presentation of an old context does not facilitate retrieval of the global learning episode, because local environmental contexts do not associate with such a global episode. Rather, each item is separately associated with the context in which the item was presented at study. Therefore, each old local context will serve as a retrieval cue only for the corresponding item. Consequently, the presentation of old contexts will produce a positive context-dependent effect on the hit rate. In contrast, presentation of old contexts will do nothing for any new item, so that presentation of the old contexts will produce no context-dependent effect on the false alarm rate. On the other hand, if the context cue is too weak to serve as a retrieval cue for old items because of cue overload, the context will play another role where the context will increase the memory strength or familiarity of the items regardless of whether the items are old or new, as posited by the ICE theory.

The ICE theory posits that recognition of the past episode involves judgment processes based on global activation of the item (*I*), the context(*C*), and ensemble information (*E*) in probe and memory. The item is defined as any information that is central to the primary cognitive task being performed in the processing environment. The context is defined as any information that is incidental to the processing of items. The ensemble is defined as a type of information that a learner forms by combining or integrating item and context information. Note that the ensemble is a unique type of information that is different from either item or context information considered alone. A general formulation for a global memory system is given by

$$M = \sum_{j=1}^{K} f(Ij,C,E) \tag{1}$$

where M represents global activation or match strength, K is the number of activated memory representations, and f is the activation function, I_j represents the strength of the match between the jth item information in the cue and in memory, C represents the strength of the match between associated context information in the cue and in memory, and E represents the strength of the match between the ensemble information in the cue and in memory.

The respective patterns of match or mismatch between the three types of information (*I*, *C*, *E*) in memory at a typical recognition test are as follows. Item information matches if the test item is old regardless of whether the test context is old or new. Similarly, context information matches if an item is tested in the old context regardless of whether the test item is old or new. In contrast, ensemble information only produces a match for old items tested in the old context. This is because the ensemble is a unique integration of the old item and the old context. For the ICE theory, Murnane et al. (1999) made an auxiliary hypothesis that the probability of ensemble formation is a function of the amount of meaningful content in the context information. More specifically, simple visual context is difficult to be integrated into an ensemble with items, because it is poor in semantic information. In contrast, background-picture or photographic context is easy to be integrated, because it is rich in semantic information (Murnane et al., 1999).

The ICE theory has explained well local environmental context-dependent recognition (Murnane et al., 1999). Almost all of the local environmental context studies have provided evidence supporting the ICE theory by using simple visual context and background-picture contexts (Dougal & Rotello, 1999; Hockley, 2008; Hockley, Bancroft, & Bryant, 2012; Murnane & Phelps, 1993, 1994, 1995; Murnane et al., 1999). Although two studies provided evidence against the ICE theory (Gruppusso, Lindsay, & Masson, 2007; Macken, 2002), further reexamination indicated that their results are rather consistent with the ICE theory (Hockley, 2008; Hockley et al., 2012). These findings suggest that the ICE theory provides the most plausible explanation of