Composites, Compromises, and CHARM: What Is the Evidence for Blend Memory Representations?

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Metcalfe's (1990) distributed memory model simulates many misinformation effects by assuming representations that superimpose information from multiple sources. In the present article, two types of evidence are reviewed for such "blend" representations: *composite recollections*, including items from both the original and postevent sources (e.g., a previously seen intersection is remembered with a subsequently suggested stop sign), and *compromise recollections*, including features that cannot be exclusively associated with either source (e.g., a green car that was later suggested to be blue is remembered as bluish green). The considerable evidence for composite recollections provides little support for blend representations. Compromise recollections, though seemingly more persuasive, are both rare and interpretable without postulating blend representations. Speculation is made about potential findings that would support blend representations.

A particularly well-documented phenomenon in memory research is the observation that subjects' reported recollections of an event can be influenced by misleading postevent information. For example, Loftus and her associates (Loftus, Miller, & Burns, 1978; Schooler, Gerhard, & Loftus, 1986) have observed in many studies that subjects who witness a slide depicting a car stopped at a yield sign and then read a questionnaire that falsely presupposes a stop sign, often later remember seeing a stop sign. To date, more than 100 studies have explored the nature and boundary conditions of this phenomenon, widely known as the misinformation effect. Despite the plethora of research in this area, there have been few attempts to develop a formal theory of the specific processes and representations involved. Metcalfe (1990) helps to fill this void with her recent application of a distributed memory model called Composite Holographic Association Recall Model (CHARM). CHARM is able to simulate a variety of the effects observed in the misinformation paradigm by assuming that memories are stored as composites. The composite representations in CHARM are derived by the process of convolution, in which the to-be-associated items are multiplied together in an association matrix and the matrix is then compressed into a single composite trace (see also, Metcalfe, 1982). By way of analogy, the composite representations predicted by CHARM can be thought of as superimpositions, such as might be observed if two transparencies were placed together. Although the mathematics underlying the CHARM model are unique to holographic memory models (e.g., Murdock, 1982), the resulting representa-

tions are similar to that of other distributed memory models (e.g., McClelland & Rumelhart, 1986).

CHARM's assumption that the representations of the original and postevent information are superimposed or blended in memory is attractive because, as Metcalfe formally demonstrates, blends provide a way to understand a number of misinformation findings. For example, if subjects recall a superimposition of both the original and suggested information then, when possible, they should most prefer to select a response that reflects a compromise between the two sources. Loftus (1977) observed just such compromises in an experiment in which subjects witnessed a green car, read that it was blue, and later indicated using a color wheel that it was bluish green. When a compromise response is not appropriate (e.g., there is no such thing as a stop/yield sign), then a superimposed memory should have different effects, depending on the testing conditions. If subjects are forced to decide between the suggested alternative and the original alternative, then subjects who have superimposed memories of both sources should be more likely to select the suggested alternative than subjects whose memories exclusively correspond to the original source, thus, accounting for the standard misinformation effect. If, however, subjects are forced to decide between the original memory and a never-before-seen alternative, then subjects with a superimposed memory should prefer the original alternative, as it at least shares some of the properties of their superimposed memory. The attenuated effect of misinformation when the suggested alternative is omitted as a response alternative has also been observed (e.g., McCloskey & Zaragoza, 1985). Finally, if subjects have a superimposed memory, then, when given the option, they might be expected to indicate that both items were observed. Indeed, when allowed, many subjects who received misinformation do report seeing both the original and the suggested items (e.g., Tverksy & Tuchin, 1989).

Given the utility of memory superimposition or blending as way of accounting for a variety of misinformation findings, it is understandable that Metcalfe and others (e.g., Loftus, Schooler, & Wagenaar, 1985; Schooler & Loftus, 1986) have suggested that such representations underlie the misinforma-

tion effect. However, as attractive as memory blends may be, some caution is still warranted in using blend representations as an umbrella construct for tying together the misinformation literature. Specifically, the evidence for such representations remains somewhat scant. Moreover, there are other explanations for the data that do not require the assumption of memory superimpositions.

Before exploring the viability of Metcalfe's assumption of superimposed memory representations, it will be helpful to define a few terms. Although Metcalfe is very precise in modeling memory blends, her terminology for discussing what empirical phenomena constitute a blend is somewhat vague. For example, she refers to typical misinformation findings in which people incorporate suggested items into their recollection of an event as evidence that "human memory may be subject to blending of single events into composites" (p. 145). Later, Metcalfe discusses "a positive memory blend" (p. 156), in which subjects identify an item that represents a compromise between the original event and postevent suggestion. Metcalfe also uses the term "blend" to characterize the underlying composite representation that she argues is responsible for these various effects. In short, Metcalfe uses the term "blend" to describe various different phenomena, as well as the hypothesized representations that CHARM uses to account for those phenomena.

In keeping with Metcalfe's attempt to add greater precision to discussions of the effect of misinformation, we suggest the following terminology. First, the term "memory blends" is itself problematic because it is unclear whether it refers to subjects' memory performance or their underlying representation. Consequently, we propose that a distinction be made between "recollection blends," which correspond to subjects' memory reports, and "representation blends," which refer to a specific hypothesis about the relationship of the underlying memory traces. Second, with respect to "recollection blends," we think that it is critical to distinguish between two general classes: composite recollections and compromise recollections.

A composite recollection combines intact items from both the original and the postevent sources. Each item in a composite recollection can be directly attributed to one or the other source. For example, in the standard misinformation paradigm, subjects may combine items from the original visual memory (e.g., a car or an intersection) and items from the postevent information (e.g., a yield sign) and produce a recollection that includes information from both of these sources (e.g., a car at an intersection with a yield sign). In contrast, a compromise recollection includes at least one feature that cannot be exclusively associated with either the original or the postevent sources, but which reflects some compromise between two different, previously encountered values on some continuous dimension. An example of a compromise recollection is the Loftus (1977) color shift experiment, in which a green car is remembered as bluish green following the postevent suggestion that the car was blue.

As will be shown, the evidence for compromise recollections is far less strong than that for composite recollections. Moreover, although, as Metcalfe argues, similar mechanisms may account for both types of blend responses, there are distinct

plausible explanations for the two types of errors that draw on quite different processes. A brief review of the evidence and explanations for these two types of memory blends raises questions about the assumption that a blended memory representation accounts for both effects.

Composite Recollections

Evidence

The misinformation paradigm provides plenty of evidence for composite recollections in which distinct items from different sources are remembered as having come from the same source. When subjects are given the opportunity, their recollections of the original event often include both the suggested item and a substantial amount of information associated with the original event (for a review see Loftus, Korf, & Schooler, 1989). Findings of this type clearly suggest some type of composite recollection (i.e., the recollection includes features drawn both from the original event and the postevent information).

Composite recollections that combine items from two sources are not limited to the misinformation paradigm. The Bransford and Franks (1971) paradigm, in which subjects falsely remember words from two different sentences as having occurred in the same sentence, is also a composite in the sense that details from two different sources (in this case sentences) are remembered together. Many autobiographical memories similarly involve composite recollections. It is common to recall the details of an event such as a trip to the beach, only later to discover that the components of that recollection were drawn from two different trips. Neisser's (1981) analysis of John Dean's memory elegantly documents the composite characteristics of autobiographical memory. Apparently, Dean's recollections of specific meetings often combined details of meetings that had occurred at different times.

Mechanisms

Although the evidence for composite recollections is quite strong, the mechanism for them is less certain. Metcalfe's CHARM model assumes that similar memories are stored together as blend representations. Thus, Metcalfe's model assumes that postevent information actually transforms the original memory by adding additional information to it (see also Loftus et al., 1985). Other accounts of composite recollections do not assume that the source representations are merged. For example, McCloskey and Zaragoza (1985) argue that subsequent information has no effect whatsoever on the original representation. Another explanation of composite recollections is that the two sources are stored separately and that retrieval conditions determine how each source contributes to the final recollection (Christiaansen & Ochaleck, 1983; Morton, Hammersley, & Bekerian, 1985).

Composite recollections may also involve source confusions (i.e., the details are retrieved, but the tags indicating where the details were acquired are not; Lindsay & Johnson, 1989.)

Such source confusions would not require that the sources were combined, but might rather result from combining subjective familiarity derived from distinct sources. Subjective familiarity (i.e., the global subjective sense of having seen something before, has been shown to be an important component of many recognition decisions; e.g., Mandler, 1980). Moreover, it is now well established that distinct and often irrelevant sources of familiarity can combine to influence subjects' judgments (for a review, see Jacoby, Kelley, & Dywan, 1989). A similar mechanism might occur for composite recollections such that subjects quickly recognize the alternative that produces the greatest familiarity, not realizing that the familiarity for that alternative is derived from two sources. Indeed, Loftus, Donders, Hoffman, and Schooler (1989) observed that subjects identified experimenter-suggested alternatives quickly and confidently, as might be expected if they were basing their judgments on an initial sense of high subjective familiarity (Atkinson & Juola, 1973).

In short, composite recollections that combine items from different sources are not very informative with respect to assessing Metcalfe's claim that memories are actually stored as blend representations. This problem arises because each component of a composite recollection can be directly attributable to a specific source. Thus, composite recollections may reflect retrieval from multiple distinct sources.

Compromise Recollections

A seemingly more persuasive type of evidence for blend representations comes from situations in which people recollect an item that, though resembling each of its sources, most closely corresponds to a never-encountered compromise between the two. Metcalfe argues, as have others in the past (e.g., Loftus et al., 1985), that compromise recollections provide the most compelling evidence that the two representations have actually "blended." Accordingly, because the compromise response does not match the items in either of the sources, it becomes more difficult to attribute it to any single source. Thus, as Metcalfe indicates, the existence of compromise recollections is a central prediction of the blend memory representations that CHARM assumes.

Unfortunately, there are a number of problems with existing compromise recollection findings for supporting blend representations. First, in contrast to composite recollections described above, compromise recollections are supported by surprisingly little evidence. Second, there are plausible mechanisms (not mentioned by Metcalfe) for accounting for compromise memories that do not require the assumption that memories are stored as composites.

Evidence

Although Metcalfe argues that compromise recollections are "perhaps the most compelling experimental evidence for blends" (p. 36), she only discusses one study, Loftus's (1977) blue-green color shift study, that observed compromise recollections. Metcalfe correctly notes that the Loftus (1977) color shift experiment is "a rather isolated instance within the

literature on eyewitness testimony" (p. 156). Although Metcalfe does not discuss them, there have been a few other published studies that directly explore compromise recollections, and these have provided relatively weak support for the concept. Loftus (1975) reported a study in which subjects saw a group of 8 people and then heard the group referred to as containing either 12 or 4 people. On a subsequent recall test, subjects' responses reflected small shifts toward the suggested number. Although this study is consistent with a blend representation interpretation, it also might have resulted in the following manner: Subjects who saw the original group may not have counted the number precisely, but may have had made a rough estimate that the group included approximately 8 people; misleading information may have then simply biased subjects to choose either the highest or the lowest possible value commensurate with this estimated range. (This interpretation will be further developed later.)

Surprisingly, although Metcalfe considers the color shift paradigm to provide the most persuasive evidence for blend representations, she neither discusses nor even cites Belli (1988), which is the most recent article exploring the paradigm. In Belli's study, subjects saw a green pitcher that, for subjects in the Misled condition, was later referred to as either "blue" or "yellow." As in the earlier study by Loftus, subjects used a multihued color wheel to identify the color that they remembered seeing. Subjects who received the "yellow" misinformation actually selected compromise colors (i.e., yellowish green or greenish yellow) approximately 9% less frequently than did control subjects. Subjects who received the "blue" misinformation selected compromise responses (i.e., bluish green or greenish blue) only slightly (8%) more frequently than did control subjects. Although misinformation produced rather few "blend" errors, it substantially increased the percentage of subjects who selected the suggested color, uninfluenced by the original color. Approximately 21% of subjects who received "blue" misinformation identified pure blue hues, compared with 2% of control subjects. Similarly, 26% of subjects who received "yellow" misinformation identified pure yellow hues, compared with 2% of control subjects. Taken together, Belli's results clearly show that subjects were influenced by the misinformation, but provide little support for compromise recollections.

Metcalfe suggests that, although the incidence of compromise recollections in the eyewitness literature may be limited, their existence is supported by the prototype formation paradigms, in which subjects falsely recognize never-before-seen prototype formations that typify the regularities exhibited by a number of previously seen exemplars (e.g., mean distance between points). However, the observation that "compromise-like" responses occur when subjects have been exposed to many different sources may not directly generalize to the blend memory paradigm involving only two sources. Homa (1984) has shown that reducing the number of exemplars from 12 to 4 dramatically reduces subjects' ability to learn prototypes. Although the issue of the minimum number of exemplars necessary to cause subjects to falsely recognize never-before-seen prototypes has never been explicitly studied, it is quite possible that prototype misidentifications might not be observed with only two exemplars. It seems quite

plausible that, as the number of stored exemplars increases, the probability that subjects will be able to rule out a "never seen" prototype decreases. Or, put another way, the more exemplars there are in memory, the more likely it is that confusions between the stored exemplars may occur. An example may help to illustrate this point. If one sees many different van Gogh paintings, it is possible that one might mistakenly recognize a never-before-seen painting that typifies that style. However, it does not necessarily follow that if one sees two van Gogh paintings, one depicting late afternoon and the other dusk, that one will superimpose the two and produce a sunset.

Although Metcalfe does not mention these sources of evidence, other researchers (e.g., Loftus et al. 1985) have suggested that blend representations are supported by the observation that verbal labels of ambiguous visual shapes or colors can bias subjects' subsequent memory reproduction and recognition toward items that are more commensurate with the verbal labels (e.g., Bornstein, 1976; Carmichael, Hogan, and Walter, 1932; Daniel, 1972). Although the effects of labeling ambiguous stimuli are consistent with the notion of blend representations, many of these findings are problematic because the labels are typically provided during encoding and therefore may affect the initial encoding, rather than altering an existing memory trace, as is the hypothesized mechanism for compromise recollections (but see Hanawalt & Demarest, 1939). Moreover, as will be described shortly, these labeling effects can be readily accounted for without assuming composite representations.

In sum, although compromise recollections are naturally predicted by distributed memory models such as CHARM, they remain in need of further substantiation. Compared with the evidence for composite memory recollections, there is relatively little evidence for compromise memory shifts in the misinformation literature; the most recent examination of the phenomena (Belli, 1988) had trouble finding them at all. Although the prototype formation literature has examples that "compromise-like" performance is observed following exposure to multiple exemplars, it is unclear whether similar processes would occur with only two exemplars.

Mechanisms

Even if future research does validate the reliability of compromise recollections, it is not clear that Metcalfe is correct in asserting that they most likely reflect composite representations. For example, a variety of researchers have suggested that prototype effects do not depend on the formation of a summary representation, but rather can be explained by assuming that people's recognition and classification judgments are exclusively based on the consideration of specific previously learned exemplars (e.g., Brooks, 1978; Medin & Schaffer, 1978; Nosofsky, 1986). Of particular relevance to compromise memory shifts is Neumann's (1977) exemplar-based model of categorization that incorporates an "interval storage hypothesis." Neumann's interval storage hypothesis "assumes that the representation of values on continuous dimensions is in the form of intervals rather than points" (p. 196). This approach can account for compromise values by

assuming that multiple exemplars may bias subjects toward one or the other end of a stored range of values. Applying this approach to memory shifts, it seems quite plausible that, for example, in the case of Loftus's (1977) color shift study, rather than storing a specific hue of green, subjects may store the knowledge that the car was a greenish hue. The introduction of postevent information that the car was blue may cause subjects to select the bluest value of the stored interval of hues corresponding to the car. This interval storage hypothesis could also account for the effects of labeling nonverbal stimuli (e.g., Carmichael et al., 1932) by assuming that representations of ambiguous visual stimuli include some range of values that can be biased in one direction or another by the verbal labels. In short, an interval storage hypothesis seems to be a reasonable alternative to CHARM's assumption that compromise recollections result from the formation of a summary representation corresponding to the superimposition of two traces.[1]

Summary and Conclusion

In sum, blend representations such as those proposed by Metcalfe can, in theory, account for many of the findings reported in the misinformation literature. Unfortunately, the evidence for such representations is somewhat equivocal. Although there is plenty of evidence for composite recollections that combine items from different sources, such recollection provide little direct support for blend representations. A potentially more compelling source of evidence for blend representations are compromise recollections that include features that cannot be directly attributed to any single source but that resemble a never-encountered compromise between the two. However, there is relatively little evidence for compromise recollections. Moreover, a storage interval hypothesis can account for existing compromise recollection findings by assuming that continuous variables are stored as intervals and that misinformation biases subjects to select extreme values of the encoded interval.

It seems appropriate to speculate on what type of finding would favor CHARM's blend representation hypothesis. The most persuasive evidence that subjects actually "blended" two distinct memories would involve responses that contain some type of emergent property that is only observed when subjects combine both sources. To our knowledge, no such emergent blend recollection has been observed in the memory literature. The value of emergent properties in demonstrating that infor-

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[1] It might be suggested that the storage interval hypothesis proposed here is no more than a restatement of McCloskey and Zaragoza's (1985) hypothesis that blend memories reflect "deliberate compromises between original and misleading information" (p. 385; see also Belli, 1988). The notion of a deliberate compromise suggests that subjects are aware that the answer they are giving is not what they actually saw. According to the interval storage hypothesis, the postevent information may simply serve as a retrieval cue that influences which specific value of the stored range subjects retrieve. Thus, the storage interval hypothesis does not necessarily involve the central concern of the deliberate compromise hypothesis (i.e., that subjects are intentionally attempting to make a compromise with the experimenter).

mation from multiple sources is truly integrated can be found, however, in research examining perceptual phenomenon. For example, in an ingenious study, McGurk and MacDonald (1976) showed subjects a video that visually depicted a person speaking the pheneme *ga* while auditorily presenting the phoneme *ba*. When subjects see *ga* but hear *ba*, their phenomenological experience is a compromise of *da*. Subjects rarely report hearing *da* when presented with either source alone, nor would most naive subjects a priori anticipate that *da* was a reasonable compromise between *ba* and *ga*. Thus, the McGurk effect provides compelling evidence that some type of true integration of information from the two sources must occur during perception (see Massaro, 1987).

Because the perceptual integration of information from multiple sources can result in unanticipated emergent experiences, it seems reasonable to expect similar types of emergent recollections to result from the integrated memory representations posited by CHARM and other distributed memory models. Although these recollections may not be easy to find, if CHARM and other distributed memory models are accurate in assuming blended memory representations, then emergent recollections ought to be out there somewhere.

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