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Familiarity breeds attempts: A critical review of dual process theories of recognition

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Abstract

Recognition memory and recall/recollection are the major divisions of the psychology of human memory. Theories of recognition have shifted from a "strength" approach to a dual process view, which distinguishes between knowing "that" one has experienced an object before and knowing "what" it was. The history of this approach and the two processes of familiarity and recollection are defined and their origin is located in pattern matching and organization. Various theories are evaluated in terms of their basic requirements and their defining research. Extension of the original two process theory to domains such as pictorial recognition is proposed. The main phenomena that a dual process theory of recognition must account for and future needs and directions of research and development are presented.

Familiarity breeds attempts: A critical review of dual process theories of recognition

The study of human memory in modern times has consistently dealt with the distinction between recall/recollection and recognition. Early in the modern period William James noted that we may encounter situations where "[w]e *recognize* but do not *remember* .." (James, 1890, Vol. 1, p.673). In the 20th century memory research was on the one hand determined by the functionalist/behaviorist emphases on learning and alternatively by a two-stage theory of recall and recognition. The former had little concern with recognition, such that the dominant text on "human learning" hardly mentions it (McGeoch, 1942). The two stage theory had its culmination in a collection of chapters discussing recall and recognition (Brown. 1976). The theory postulated that in recall possible target items are generated and are then subjected to a recognition test (usually based on familiarity). One of the effects of the Brown book project and its repeated critiques of two-stage theory was that the theory barely survived this assault. The time was ripe for a novel approach to recognition, and suggestions for different processes involved in recognition had occurred in the decade before the Brown volume. For example, Adams suggested "a perceptual trace that grants the power of recognition and a memory trace that governs recall" (Adams, 1967, p.270).

The actual development of dual process theories is a story about an adequate theory of recognition and the relative roles played by familiarity – a

perceptual phenomenon - and recollection – based on conceptual processes. In

a sense it is about the fate of the familiarity notion which was still a dominant

explanatory notion for recognition phenomena by the middle of the 20th century.

The notion of familiarity and its function in recognition has been used throughout

the modern period of experimental work (cf. Hollingworth, 1913, Kintsch 1967,

1970). Familiarity alone was often assigned the role of determining the

recognition of an event (Kintsch, 1968, p.243) and it was also generally believed

that prior frequency of experience was the major determinant of feelings of

familiarity.[1] The two-stage approach to recognition and recall, described above,

postulated that retrieval and recognition processes are separable, with only recall

involving any retrieval processes (Müller, 1913; Kintsch, 1968). In other words

organizational processes could not affect the recognition process.

The last half century has seen an outpouring of theory and research on

the topic of recognition. The general tenor of current conclusions is that there are

two different processes involved in recognition: Familiarity and recollection. The

volume of work is such that a thorough review or summary of the literature would

be, at least, Herculean – there are well over 1000 relevant references. Besides,

a thorough review of the existing literature as of 2002, including the

neuroanatomical evidence, has been provided by Yonelinas (2002).

The purpose of this article is to review the various theoretical proposals,

to examine their internal and applied logic, and to argue that the original dual

process model of the 1970s and related proposals provide the most satisfactory

explanation of the target phenomena. Relevant, empirical papers will be

discussed as illustrative instances. Neuroanatomical issues will not be discussed; the experimental evidence is not yet fully adequate for such speculations nor is there reasonable agreement among the neuroanatomical models (Yonelinas, 2002, and references below).

Some definitional issues

Familiarity is not a well-grounded theoretical concept; it is the best available common language label to describe a psychological phenomenon. On the one hand are the theoretical considerations that generate predictions and expectations about recognition, on the other hand are the behaviors and responses required to illustrate it. Familiarity is appropriate when the response to a word, a picture, a melody is or is close to: "I am certain that I have seen, heard, felt that event before." However it is not a mere familiarity phenomenon when the response is: "I am not sure I have seen that before, but I do seem to recall an occasion when I might have." The respondent need not necessarily understand or use the word "familiarity" – all we need is a response that we can classify as indicating something like familiarity. Since familiarity is a subjective response, it is necessary to be fairly sure which situations are appropriate for its application – specifically a familiarity locution should be a first response to an event and not dependent on subsequent search, recall, or insights. Such events as meeting an acquaintance of one's youth who seems strange at first, but later elicits the response "now you are becoming familiar" would not be a case in point. I shall discuss the possible underlying processes that generate the sense of familiarity.

It must be stressed, however, that contrary to Yonelinas (2002, p.445) none of

the possible processes considers familiarity to be a "characteristic of an item;"

familiarity arises as a result of processing some aspect of the item's structure,

function, or constituents. Thus, familiarity is not a psychological theoretical

variable but the result of such variables. Familiarity cannot produce or support

any other processes; only the underlying processes could function in such a

fashion.

. Recollection, in contrast, does involve a memory search and there is

relatively little argument as to the processes involved. Recollection has been the

preferred term in recent years, replacing recall in that role, but there is little

experimental or theoretical difference between the two. Specifically, for present

purposes recollection/recall depends on the semantic (meaningful) organization

in which the target item is embedded and which permits retrieval.

Dual-process theories

I describe the various dual process (DP) theories in rough order of their

appearance in the literature. The first two appeared at about the same time from

the Mandler and Atkinson laboratories respectively. I describe our model more

extensively than others because the purpose of this presentation is to argue for

its general applicability.

The Mandler model

The original outline of DP theory was presented in 1969 (Mandler,

Pearlstone & Koopmans, 1969) as a result of experiments which tested the effect

of organizational variables on recognition performance. In contrast to received wisdom and previous analyses of recognition, the data showed strong organizational effects in recognition. Initially we ascribed these phenomena to a post-recognition retrieval check in which the initial perceptual analysis is followed by an organizational retrieval/recall test (see also Mandler, Meltzer & Pearlstone, 1969).

Perceptual information and retrieval are used in combination so that if a target is not immediately recognized (on the basis of perceptual familiarity) one searches memory for additional information, and retrieval may provide the identity of a familiar target. In common experience, the theory accounts for being able to say "that" one has previously encountered an object (on the basis of familiarity) and identifying "what" the object is (on the basis of recollection). Full recognition involves knowing both "that" and "what." In the absence of familiarity information, however, recollection may provide some approximation of the recognition experience.

There are two time courses of interest for experimenter-presented material. First, there is the response time to recognize an item that has been previously presented, and second there is the delay between original presentation and test. As far as the first of these is concerned, immediate recognition responses based on perceptual information should be contrasted with slower responses which would imply recollection/recall. Mandler and Boeck (1974) tested recognition a week after the presentation and organization of a list of words. They demonstrated that degree of organization (defined by material

sorted into two to seven categories) had no relation to the fast recognition responses but that for slow recognition responses items that had been subject to finer grained organization were more likely to be recognized than less discriminately organized items. Slow recognition responses are the product of the organization of the target material, whereas fast ones are based on familiarity and may be unaffected by organizational variables. The second time course of interest was investigated by Mandler, Pearlstone & Koopmans (1969; see also Mandler 1980). The variable of interest is the time interval between the original presentation of a list and a recognition test; with the decay of perceptual information the retrieval operation becomes more useful for recognition decisions. Subjects were presented with categorized (organized) lists of words, and over increasing intervals (up to 5 weeks) between presentation and test the organizational variables showed increasing effects on recognition. The percent of variance of recognition performance attributable to organization (categories used to organize the lists) rose from 7% to 46%. Among the evidence that recognition was unaffected by organization during an initial phase was the fact that synonyms did not show a false alarm rate higher than unrelated words on tests immediately following presentation.

The theory postulated two memorial processes. One was a perceptual process – later identified as involving pattern matching – which was the mechanism responsible for the experience of prior occurrence (eventually labeled with the more accessible "familiarity") of having experienced the event before (in some sensory modality). The other process was a classical recall process –

originally identified as a retrieval check - which provided the retrieval of the stored memory representation of the target event and produced the experience of being able to identify the target event. Being able to recall the target item in the absence of familiarity may convince observers that they have experienced the event before, even though there is no perceptual evidence for such a conclusion. These considerations summarize dual process theory – the distinction between perceptual occurrence information and organized knowledge. The initial identification of the two processes was followed by a series of experiments that explored the distinction between occurrence/familiarity information and the elaborative processes that organize the target material (Mandler, 1972). Organizational processes were shown to have not only the well known major influence on the recall, but also on the recognition, of previously presented items. For example, recognition failure was shown to be due to a failure of the organizational processes of the dual process mechanism (Rabinowitz, Mandler & Barsalou, 1977).

In a summary of these results (Mandler, 1980), the major adjustment was the assumption that fast familiarity processes and slow recollection processes occur in parallel, with the familiarity response "winning the race." The defining every day example of a pure familiarity response was the "classic 'butcher on the bus' phenomenon," as Cleary, Morris & Langley (2007, p. 380) describe it. The example involved the recognition of one's butcher in a bus as familiar, without being able to identify him until he is seen in the context of his shop (Mandler, 1980).

A parallel theoretical paper (Mandler, 1979) also presented the possible underlying structure for both familiarity and retrieval. Two major underlying dimensions are postulated as responsible for familiarity and recollection respectively – integration and elaboration, shown schematically in Figure 1. The vertical dimension of integration is related to the increasing invariance of its components and their interrelations/connections. The primary aspect is not the identity of the particular components but rather the relations among them. With repeated experience the links between the components become more permanently established. New components can be added but the major function is the increasing rigidity of the structure. When an event or object in the environment or in experience matches the pattern (or template) of the underlying representation it produces the subjective feeling of familiarity. The more frequently and recently the representation of an event has been integrated the more likely it is that the presented pattern will be matched. Essentially the matching of the event and the underlying representation becomes an instance of perceptual pattern matching, and patterns of words, pictures, events feel familiar when there exists a previously established integrated pattern that matches the experience. It is by way of this strengthening of the links among the constituent characteristics that one learns what dogs or blueberries look like, what events define a baseball game, what characteristics identify a Rembrandt painting. Elaboration of the other hand involves an articulated semantic network which permits search processes and retrieval of previously stored information. Increasing experience produces richer and more elaborated networks that permit

access to stored experiences, usually from more than one point of view. Through organization and elaboration one learns that a particular dog is the neighbor's pooch, that a particular game on television involves the New York Mets, how to identify a particular painting. Thus being faced with an object or event there will either be an immediate (or fast) pattern match of varying degree of confidence or, in the absence of a successful match, a search process for a stored representation of the target item (Mandler, 1979, pp. 299-304). Empirical tests of the model showed satisfactory fits when recall is used as a measure of organization, and recognition is considered to be the joint operation of familiarity and recollection/retrieval.

The model in Figure 1 also illustrates the operations underlying the time course of recognition. If an event matches a well integrated (frequently encountered) patter a familiarity judgment will ensue quickly. If, however, the event either does not match the pattern or does so weakly a search process is initiated which will require additional time. Furthermore the weaker the pattern match and the longer the ensuing further search for a familiar event pattern the more likely is it that the search process of the elaborated memory traces will be invoked.

A further extension of the dual-process model in 1991 (Mandler,1991) dealt with such topics as paired-associates, the performance of amnesic patients, and word completion. Concerning the word frequency effect mentioned above, Mandler, Goodman & Wilkes-Gibbs (1982) had shown that the effective integration/familiarity of an item is dependent on the relative increment due to the

presentation itself, and such an increment is greater (relative to the original integration) for low frequency than for high frequency words. The ratio model for the word frequency effect had also been described previously, e.g., by Atkinson & Juola (1974).

I shall have occasion below to discuss the applicability of two process theory to such phenomena as picture recognition. Before moving to other theoretical approaches, I note relevant developmental observations. Similar to the priority of familiarity in the familiarity-recollection process, there occur cognate developmental sequences. Infants display novelty/familiarity reactions to visual stimuli as early as the first week of life (cf. Slater, Morison & Rose, 1984). On the other hand, indications of recollection, as indexed by imitation delayed by 24 hours, do not appear until about the 6th month (cf. Barr, Dowden & Hayne, 1996). Thus, infants early on generate a sense of familiarity with the perceptual world, but do not have access to conceptual representations (as needed in recall) until much later.[2] It appears that the developmental sequence of familiarity and recollection is recapitulated in adult recognition.

The Atkinson model

At the same time that Mandler's approach was being developed, **Atkinson** and his colleagues independently generated their DP model.[3] The development started with a paper by Juola, Fischler, Wood & Atkinson (1971) and was followed by further elaborations in Atkinson & Juola (1973, 1974) and Atkinson, Herrmann & Wescourt (1974).[4] The model described an initial search process

which produces a fast response generated by occurrence information. If that search does not produce an unequivocal response, subjects engage in a memory search. Occurrence information (familiarity) is generated by activated nodes that represent individual items and that can be evaluated in terms of signal detection theory (SDT). The SDT modeling assumes that the distributions for old and new items are overlapping. Both upper and lower criteria are set that accept or reject relevant familiarity levels. It is for the items falling between the upper and lower criteria that the recall process is invoked. In essence, there is no significant difference between the two early dual process models.

Jacoby's fluency model

Jacoby and co-workers developed their model (Jacoby & Dallas, 1981) out of an initial interest in the difference between perceptual and elaborative processing. Following the dual process models, they stipulated that recognition depended on (a) variables that affect perceptual processing and (b) elaborative context probably related to levels of processing (Craik & Lockhart, 1972). The perceptual aspect is based on the fluency of processing which produces feelings of familiarity. They also noted that recollection/retrieval is a consciously controlled process, whereas fluency/familiarity is a nonconscious automatic process The model also suggested that knowing that an item is processed fluently can lead to the interpretation that the fluency reflects prior experience and such a conclusion generates feelings of familiarity. Although it is difficult to distinguish between fluency and speed of processing, Jacoby & Dallas accept that these perceptual

processes are faster than recollection. In general then their model is consistent with the earlier DP models. The two processes are assumed to operate in parallel.

In a subsequent experiment Jacoby and Whitehouse (1989) examined false recognition of words not previously presented. They preceded each of these "new" words either with the same or a different word, either sub- or supraliminally – which differentiates Jacoby's distinction between automatic and aware processes.. They found that by preceding words that had not been previously presented subliminally with the same words increased the false recognition of the target word but that supraliminal presentation of the target words decreased false recognition. In terms of our initial dual process theory, the subliminal presentation would increase the integration of the target words, but not affect the recollective process. On the other hand, supraliminal presentation would encourage search processes - "Did I see that word before?" - and in a significant number of cases would produce a negative response. The argument for such a process is supported by Jacoby and Whitehouse's finding that in the supraliminal condition subjects "were less likely to correctly recognize a test word that was not preceded by a context word than they were to recognize a test word that was preceded by either a matching or a nonmatching context word." In terms of dual process theory one would expect that the priming due to the recollection process (when successful) would produce an increase in "hit" rates, whereas the word by itself depended on whatever integration processes were appropriate. Jacoby & Whitehouse ascribe the absence of false recognition in the case of the

supraliminal context words to a discounting of familiarity due to perceptual fluency. That argument has been challenged in a series of experiments by Huber et al (Huber, Clark, Curran & Winkielman, Submitted) that parallel the Jacoby & Whitehouse experiment – in the context of a high degree of source confusion. Given the role of pattern matching in the origins of familiarity it would be important for the presented item to be unequivocally the target of the recognition identification. However, under these conditions of source confusion there is an impairment of pattern matching. The failure, consistent with Jacoby & Whitehouse's invocation of disfluency, is ascribed by Huber et al to excessive priming which saturates primed items. (see also Huber & O'Reilly, 2003).

Cleary's model – Patterning and structural regularity

Cleary and associates presented two reports and discussions which are related to the familiarity problem (Cleary & Greene, 2000; Cleary, Morris & Langley, 2007). The first paper was based on a set of observations by Peynircioğlu (1990) who presented fragments of studied words and of nonstudied lure words for completion, followed by a decision whether the fragments were on the list or not. More of the noncompleted fragments of list words were judged as list words than noncompleted fragments of lure words. In other words, fragments of previously studied words were considered as having been presented even when the words whence the fragments came could not be identified as having been on the original list. Cleary & Greene replicated this finding and concluded that even when subjects failed to complete fragments successfully their

recognition of the fragments as old was above chance. In other words familiarity judgments were made successfully in the absence of a recollection of the words from which the fragments came. Even though the authors had expected recognition to be organizationally based, they conclude that orthographic information (patterning) may be important in recognition. Langley et al (Langley, Cleary, Kostic & Woods, 2008) demonstrated that the paradigm could be extended to picture recognition. Using masked pictures of common animals and objects they found that old/new discriminations could be made of unidentified pictures, concluding that the pictures are recognized on a perceptual level. Related to this finding is research that showed that the recognition of classical paintings was significantly faster than judgments of liking of these paintings (Mandler & Shebo, 1983). It would be interesting to extend these findings to more general notions of aesthetic identification and judgment.

Another case of patterning is addressed in Cleary, Morris and Langley (2007). They extend the previously known observations of structural regularity, such as orthographic regularity (Miller, 1958). Structural regularity improved the recognition of novel stimuli. Structural regularity benefits old-new recognition/discrimination, showing that previously established patterning benefits recognition. In general the data from Cleary's group support the notion that integrated pattern of words, pictures, etc. support the general pattern matching approach to familiarity. A common mechanism for the familiarity of music and odors has been also been suggested by Plailly, Tillmann, & Royet (2007).

Cleary and associates also discuss an entry into the recognition discussion by Whittlesea and colleagues, which addressed the question of familiarity, but not the DP theories. Cleary & Greene (2000) cast doubt on the demonstration that structural regularity produces false positive responses (Whittlesea & Williams, 1998). Cleary et al. (2007) also reject the discrepancy-attribution hypothesis as a basis for familiarity (Whittlesea & Williams, 2000).

The Yonelinas model

The Yonelinas model was developed during the 1990s (cf. Yonelinas 1994, 2002). In contrast to the other models which postulate a familiarity process followed by or parallel to a recollection attempt, this approach postulates that different characteristics of the target event are accessed on presentation. The inability to retrieve qualitative information (recollection) about an item will result in a judgment based on familiarity, which is based on memory strength. Recollection is postulated to be responsible for high confidence recognition judgments. However, Yonelinas also asserted that the two processes operate in parallel and that familiarity processes are faster than recollection (Yonelinas, 2002, p.446), which would also permit a sequential appearance of the two processes.

Gardiner and the know/remember model

The most recent and a widely used entry into the dual-process collection is the know/remember distinction, and because of its frequency of use deserves an

extensive discussion. The model is based on Tulving's (1972) distinction between episodic and semantic memory. Tulving defined episodic memory as personal memories and the relations among them, whereas semantic memory is conceptual and includes memory for words and other symbols, the relation among them, rules about their interaction, as well as general world knowledge. The distinction has not been without its critics and in response to a major critical evaluation by McKoon et al (McKoon, Ratcliff & Dell, 1986), Tulving (1986) concluded that the episodic-semantic distinction is an interesting idea that needs logical, empirical, and theoretical development, but is not subject to the hypothetico-deductive method, since it is primarily a classificatory scheme. The episodic/semantic distinction was taken up by Gardiner and associates following Tulving's (1985) interpretation of "remember" as indicating one state of awareness associated with retrieval from episodic memory and "know" as a different state indicating retrieval from semantic memory. There is a degree of vagueness about the distinction that makes it difficult to interpret the relevant literature. The vagueness is illustrated in the use of the remember/know distinction in recognition. The method generally used is described by Tulving (1985) as requiring subjects first to make yes/no recognition decisions about test words and then to decide for "yes" words whether they were remembered or known. The supposition is that Remember responses required that something about the presentation condition was recollected, whereas Know responses implied that that was not possible, but the word was recognized "on some other basis." In later experiments that judgment was usually interpreted to mean that

the word was familiar or similarly experienced. This sense of "knowing" is obviously different from the original definition of semantic memory as general knowledge of words and their semantic relationships.

The empirical work on the remember/know distinction was developed primarily by Gardiner and associates (e.g., Gardiner & Java, 1990; Gardiner & Richardson-Klavehn, 2000). Gardiner (2001) advances a distinction between the experience of knowing which emphasizes feelings of familiarity and "just knowing" which apparently does not include such feelings. Gardiner argues that under some "conventional point of view" recognition decisions are objective whereas remember/know judgments are subjective; but both are obviously subjective responses. Recognition decision are postulated to be a summation of remember and know judgments which is the core of this version of dual process theory. The unusual use of subjective judgments as independent variables is described as "first person" psychology. However, by using as independent variables two (apparently correlated) subjective judgments undermines the attempt to assess independent effects of knowing/familiarity and remembering/recall.[5] It is never quite clear whether know/remember judgments are subjective responses, theoretical variables, or both. Yonelinas (2002, pp.453-4) has noted difficulties of the remember/know distinction within the dual-process paradigm, such as the inadequacy of "know" responses as measures of familiarity, the likelihood that guess responses are simply "weak" know responses, and the problem of relating subjective experiences to underlying

theoretical processes. Yonelinas implies that a simple confidence dimension can account for the remember/know data (see also Dunn, 2004; Hirshman, 1998).

Remember/know experiments require instructions to the subjects on how to use the two relative judgments. However, even brief consideration makes it obvious that both kinds require some retrieval and both involve feelings of familiarity. Knowing that Paris is the capital of France requires some (though brief) search mechanism and produces a feeling of familiarity whereas remembering the last time one was in Paris requires a search mechanism and also produces a sense of familiarity with the recovered event. Forcing subjects to make binary decisions does not reveal the underlying processes involved. Current evidence and criticisms by increasing numbers of investigators leads to the conclusion that the know/remember dimension is best represented as a single dimension of memory strength (Donaldson, 1996; Dunn, 2004; Hicks & Marsh, 1999; Rotello & Macmillan, 2006; Wais, Mickes & Wixted, 2008; Wixted & Stretch, 2004).

Current status and future directions for the dual process model

In an extensive review of the recognition literature, Dana, Reder, Arndt & Park (2006) concluded that "models of recognition must include a recollection process" (p. 18). They advocate more future research on the manner in which recollection contributes to recognition, and suggest that formal models, such as the SAC (source of activation confusion) model (e.g., Cary & Reder, 2003) could contribute to such a search. Yonelinas (2002) had similarly assumed that single

process models have been shown to be inadequate. Thus, while there is a general agreement that recognition involves two processes, there are still important dissenters to be discussed. One that has been given too little attention is the exploration of recognition by Gillund & Shiffrin (1984) based on the SAM model. They argued that recognition is too fast to involve any extensive research. They also found that restricting subjects to slow or fast responses did not interact with other variables. However, their recognition tests occurred immediately following the presentation of the original lists and under these circumstances one would expect some constancy since the activation of the to-be-recognized pattern would be relatively available and most responses would be familiarity responses. In contrast Mandler and Boeck tested a week after original presentation and found distinct differences between familiarity and recall responses.

It should also be noted that the classical approach to the pure familiarity response in recognition provides no information as to the identity of the target object – that requires a search/recollection process. The provision of context is one way of obviating the search process; context provides the additional organized information as to the identity of the target. The butcher in the butcher shop is provided by his environment with an identity that his appearance in the bus may not.

In the following paragraphs I summarize different areas of research that appear to be useful directions in a further elaboration of the dual process models.

Extension to natural settings. Practically all the research on recognition has been carried out with experimenter-presented material. The vast majority of data has been collected within same-day presentation and testing when familiarity is likely to be at a temporary maximum. Recognition in the natural setting produces familiarity responses after months and years and – apparently – recollection processes more complicated than occur in the laboratory. Highly integrated memories and old established memory clusters deserve experimental attention. Clearly additional research is needed to illuminate these various questions.

Time course of the two processes. One approach to bring laboratory and natural recognition phenomena under the same umbrella involves more detailed analyses of the time course of the recognition process. Our data on the fast familiarity responses and the increasing importance of organization over time since presentation represent just two data points. Yonelinas (2002) has argued that familiarity decreases more rapidly than recollection; others have argued intuitively that recollection should decay rapidly, in contrast to familiarity. Among future possible research approaches are variations in the length of exposure of the test items, both at presentation and at test, variations in prior experience with the test items ranging, in the case of words, from high frequency words to nonwords. In our tests the effect of organization on recollection was generally high and increased over time because of the effective prior organizational training with the target items – other possibilities exist to vary organization, including variations in the instructions to remember the words. Various changes in these

procedures may make recollection and familiarity vary in their persistence over time. If in fact familiarity is a strength process and recollection is a probabilistic phenomenon, comparison between the two should take this difference into account. As far as familiarity is concerned, laboratory conditions presumably only provide a brief reactivation of the representation of the target pattern; in natural settings these experiences are longer and longer lasting. Recollection in the natural setting depends in part on the variety and multitude of pathways that lead to a particular target item – one can recall some events better because they are more richly embedded. The remember/know paradigm is not particularly useful in this context because "remember" responses fade more rapidly than "know" responses – almost by definition.

Extension to different modalities. Any theory of recognition must apply to recognition in any sensory modality, whether the target event is read, seen, felt etc. As we have seen some version of pattern matching supports recognition in different modalities. Further work should sample the range of modalities and distinguish between the familiarity of sights, sounds, and smells and their specific identification. Tune recognition is potentially a fruitful area for applying dual process theory. Wong and Barlow (2000), for example, have described melody recognition as based on a template that is defined by pitch and time.

Quantification of the processes. There have been several attempts to quantify the two processes. The results tend to be somewhat variable, which is not surprising given the different assumptions under which different models operate. For example, intentional acquisition apparently affects only the

recollective aspect of recognition (Macken & Hampson, 1993). Yonelinas (2202) also noted that the assumptions for quantification are often violated. For an illustrative selection of these attempts, see Mandler (1980), Yonelinas (2001, 2002), Yonelinas & Jacoby (1995).

Signal detection analyses. Wixted (2007) has noted that SDT analyses of the recognition process are more consistent with an unequal variance single process model (UVSD) than with the dual process models which postulate a continuous recognition process and a high threshold process producing a yes/no decision (the DPSD model). However, for the UVSD model to be viable, recollection and familiarity need to be additively combined in a single variable of memory strength. Whether that is practicable experimentally would influence a preference for the UVSD model; if not, the DPSD model would still be alive and might be preferred in any case. At the same time, one might still consider the original SDT analyses of Atkinson and Juola (1973, 1974) in which the familiarity decision is made if the familiarity (occurrence information) falls above a high criterion or below a low criterion then an old or new judgment is made, If the value falls between the two criteria then a retrieval process is initiated. In addition, the recollection process may also be invoked when the familiarity value falls below the low criterion, This is not as clean a model as a single SDT analysis but is consistent with available data.

Characteristics of the processes. One might also pursue the notion that the recollection/recall process does not necessarily produce a yes/no retrieval but is graded or probabilistic. The response may be that the subject believes with low

certainty to have encountered the target in a certain situation, but is not sure. On some occasions this uncertainty may yield a yes, in others a no response. More generally, the process underlying familiarity (and pattern matching) is a continuous (strength) process extending from random responding to maximal matches, but the recollective process is a search process that is probabilistic; the two would have quite different distributions. Familiarity/pattern matching is an increasing function that reaches a maximum with complete matches, whereas recall/recollection is approximately represented by a normal distribution. A suggestion that the two processes may be co-active and that recognition decisions are based on the (presumably simultaneous) action of continuous familiarity and recollective processes (Wixted 2007) needs to spell out the mechanisms whereby such co-action may occur. A more detailed analysis of the conditions that affect the levels of confidence for both familiarity and recollection would illuminate the details of the dual process mechanism.

Parallel vs. serial operations. At present, it is not clear whether the current notion that the two processes operate in parallel is consistent with available data. Several variations are available on this issue; the race proposal in the Mandler model, Atkinson's suggestion that familiarity processes precede recollection, Yonelinas' potential reversal of that sequence, and Wixted's advocacy of a combination rule. This is obviously a fruitful area for further research.

Neuroanatomy. There have been a number of contradictory claims about the neurological basis of recognition. For example, see Paller, Voss & Boehm (2007), Skinner & Hernandes (2007) and Squire, Wixted & Clark (2007) for

reviews of the conflicting literature and the need for more information. More

psychological research to further clarify the operation of familiarity and

recollective operations is needed and will be useful for uncovering specific and

consistent neuroanatomical correlates.

Incomplete recognition/recollection. Finally, returning to the "that" and

"what" distinction, we need to consider such phenomena as partial recognition.

First, there is the case where familiarity registers an event as having been

previously encountered without having any further information about the target

information. The "butcher in the bus" is a prime example, and it also is one where

the problem of "what" is solved in the context of his shop. Other solutions for a

completion of the initial familiarity response are successful recall search

processes without any additional environment input, and conversely any number

or additional "reminders" that provide a successful identification. I have

mentioned the condition where a belief in "recognition" exists in the absence of

perceptual evidence. Again more data are needed on situations where one

encounters an event that is not identified as familiar but where some recollective

experience, such as "we met years ago" or "that setting was part of a description

in a book," provides recall and the appearance of recognition. Experimental

evidence is needed to explore these various partial identifications.

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Footnotes

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[1]The discovery that low frequency words were sometimes easier to recognize than high frequency ones tended to raise unanswered questions (Gorman, 1961). I shall return to this phenomenon again in my discussion of dual process theory.

[2]For a general discussion of the early perceptual/conceptual distinction in memory see J. M. Mandler (2004, Ch. 10).

[3]An example of the general conditions of the times generating similar insights, a phenomenon traditionally ascribed to the *Zeitgeist* (cf. Mandler, 2007).

[4]With Atkinson's departure to the National Science Foundation the project was not developed further.

[5]Given the past imperviousness of experimental psychology to the inroads of a subjective postmodernism, it is possible that this area of investigation is the first appearance of such an incursion (see also Mandler, 2007, pp. 221-224).

Figure Caption.

Figure 1. The underlying dimensions for familiarity and recollection. For the

horizontal elaboration dimension, the relevant structure underlying the target

items is – with experience – related to other structures and becomes an integral

part of the semantic network. The vertical integration dimension shows the nodes

at first weakly connected and becoming increasingly so with additional exposure

(with permission of LEA Inc. from Mandler, 1979).

INTEGRATION

ELABORATION
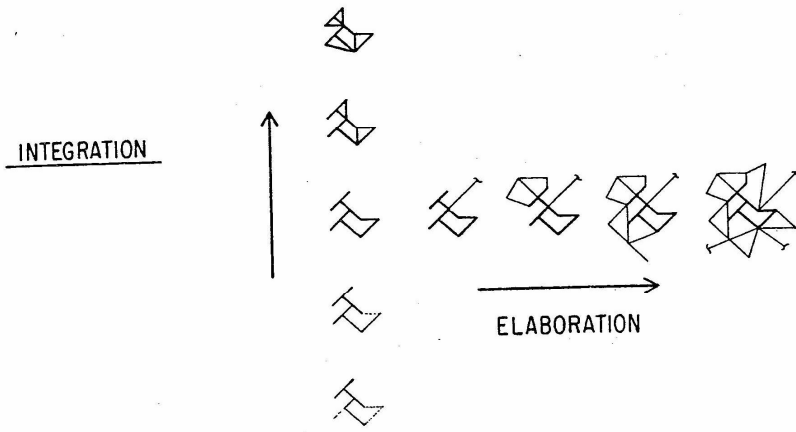
PS.Evidence for the distribution of familiarity judgments having J- curve characteristics can be found in Figure 2 of Mickes, L., Wixted, J. T., & Wais, P. E. (2007). A Direct Test of the Unequal-Variance Signal-Detection Model of Recognition Memory. Psychonomic Bulletin & Review, 14, 858-865. The figure shows that strength judgments of recognition (following a brief interval after presentation) increase to a maximum which represents the optimal pattern match. These judgments are primarily familiarity judgments. Later recall/recollection reponses would approximate the usual nornal probability distribution.