encoding operations in memory This phrase denotes cognitive activities that accompany the perception of a to-be-remembered item or event, thereby influencing the properties of the resulting memory trace.

A major empirical problem in laboratory research on memory has always been that of the identification of variables and factors that influence the "goodness" of memory performance, and the measurement of their effects. A major theoretical problem has concerned the determination of the relations between these variables and factors on the one hand, and the hypothetical component processes of learning and memory on the other. The conceptualization of an act of remembering as consisting of three successive processing stages – encoding, storage, and retrieval – has guided this theoretical enterprise in the recent past (*see* MEMORY). Thus, memory phenomena can be identified as "encoding effects," "storage effects," or "retrieval effects." When other variables are held constant in an experiment, and only the nature of retrieval cues is varied, the observed differences in memory performance can be classified as reflecting retrieval effects. When encoding and retrieval conditions are held constant, and the length and activities of the interval between encoding and retrieval are varied, the observed differences can be said to reflect storage effects. When the experimental manipulations performed at encoding produce differences in subsequent memory performance, we speak of encoding effects.

It is well known that variables such as study time, the number of repetitions, and the intention to learn facilitate subsequent performance. In the early days of the study of learning and memory, theorists even talked about corresponding "laws," such as the law of frequency and the law of recency. More recently, however, other important determinants of the goodness of encoding have been identified. The major concept in this later work is that of the encoding operation. Many findings have been reported in the literature that attest to the important role that encoding operations play in memory. Much of this work is subsumed under the concept of LEVELS OF PROCESSING.

In experimental situations, different kinds of encoding operations are induced by instructions, by manipulating the context of the to-be-remembered items, through orienting tasks, or combinations of these. Variations in encoding operations lead to differences in recall or recognition (*see* RECALL; RECOGNITION MEMORY). Thus, for example, experimental subjects can be asked to classify words, at the time of study, as belonging or not belonging to a particular category, versus just copying the words. Regardless of whether the subjects know that their retention of the words is going to be tested, they recall a larger proportion of classified words than copied words. Thus, classification is a more effective encoding operation than copying. Similarly, making judgements about the pleasantness of words is a more effective encoding operation than making judgements about the presence or absence of certain letters in the words. Instructions to subjects designed to induce particular encoding operations may also lead to more effective encoding, and hence to enhanced recall or recognition, than do general instructions to "learn" the words.

Large differences in both recall and recognition, attributable to different encoding operations, have been found in many experiments (e.g. Hyde & Jenkins, 1969; Craik & Tulving, 1975). In these experiments, all other conditions are held constant, and only the encoding operations are varied. For example, subjects may be asked to make judgements about a given word's appearance (e.g. "Is it typed in lower-case letters?"), its sound (e.g. "Does it rhyme with 'park'?"), or its meaning (e.g. "Is it a kind of vehicle?"). Subjects would

respond to each question either affirmatively or negatively.

The results of such experiments show that both recall and recognition of the studied items vary with the type of encoding operation and response category at the time of study. Semantic judgements are more effective than phonemic judgements which in turn are more effective than graphemic ones; also for the first two kinds of judgements, encoding questions requiring affirmative responses are more effective than those requiring negative ones. The superiority of semantic encoding is regularly found in most situations. But the fact that recognition is higher for semantic questions answered affirmatively than for those answered negatively suggests that semantic encoding operations can be further analyzed into differentially effective classes.

Such further analysis shows that different kinds of semantic encoding operations can also vary in effectiveness. In one experiment, for example (Mathews, 1977), people were presented with word triplets (e.g. "lion," "whale," "mammal"; or "lion," "whale," "circus"; or "lion," "whale," "metal") and were asked to judge whether both, one, or none of the first *two* words were semantically related to the third. All subjects were subsequently given one of the two first words from the triplet as a cue (e.g. "lion") and asked to recall the other one (here, "whale"). The results showed that the probability of such cued recall varied greatly – over a range of 0.10 to 0.68 – with the number of semantic relations in the study triplet.

The effects of many different encoding operations have been reliably documented in the literature, using such standard measures of memory performance as free recall and recognition. It is generally assumed that encoding operations play an important role in memory even when they are not specifically manipulated, and even when the rememberer is not consciously aware of how any particular event has been encoded. It is also known that the exact effects of any encoding operation depend on the nature of retrieval information available to the learner at the time of retrieval. These effects are subsumed under the rubric of the ENCODING SPECIFICITY PRINCIPLE.

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