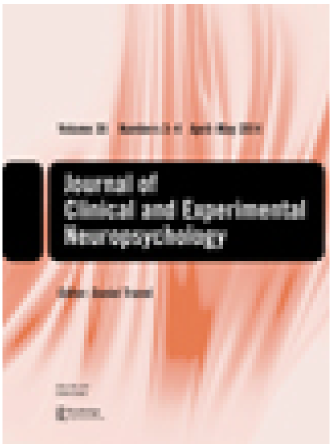

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Head-Injured Patients and Control Group: Implicit Versus Explicit Measures of Frequency of Occurrence*

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ABSTRACT

This study was conducted in order to investigate the possibility that effortful processes are involved in the retrieval stage of the putative automatic task – frequency judgment. Head-injured (HI) and control groups were tested on a frequency of occurrence task under explicit – intentional retrieval (i.e., frequency estimation) and implicit – unintentional retrieval (i.e., word-stem priming) conditions. Subjects were presented with a list of nouns that appeared once, three times, and six times. Following presentation, subjects were first given a priming task, then a recall task, and finally a frequency judgment task. Although the control group performed better than the HI group on recall and frequency judgment tasks, the groups did not differ on the priming task. The results are discussed in terms of the relationship between effortful and automatic memory processes.

Hasher and Zacks (1979) distinguish between 'learned' and 'innate' automatic processes. They view automatic and effortful processes not as two distinct categories but rather as two ends of a continuum, with the innate type located closer to the automatic extreme than the 'learned' type. The authors claim that frequency judgment, spatial location, and temporal order satisfy the criteria of innate automatic processes, such as being unaffected by subject differences (e.g., age, intelligence, and motivation) or task variables (e.g., intentionality to learn, practice, and feedback).

Over a decade later, the concept of innate automatic processing remains controversial. Encoding of frequency of occurrence (the focus of the present paper) has been the most widely studied task among the three putative innate automatic tasks (for a review, see Greene, 1990; Hasher & Zacks, 1984; Zacks, Hasher, & Alba, 1984; Zacks, Hasher, & Sanft, 1982). Some studies have shown that the criteria for automaticity set by Hasher and Zacks are satisfied (Greene, 1984; Hasher & Zacks, 1979; Kausler & Puckett, 1980), but other studies have failed to support this position (Ellis, Palmer, & Reeves, 1988; Greene, 1986; Naveh-Benjamin & Jonides, 1986; Tweedy & Vakil, 1988).

Several explanations have been offered for conflicting findings about judgment of temporal order, frequency of occurrence, and also for spatial location. Some have suggested modifying the definition of automaticity by restricting the required criteria (Naveh-Benjamin, 1987). Others have suggested that performance may be viewed as a continuum between effortful and automatic (Naveh-Benjamin, 1987; Sanders, Gonzalez, Murphy, Liddle, & Vitina, 1987). Yet another explanation is that the putative automatic functions involve many subprocesses or comprise different components that vary in their degree of automaticity (cf. Naveh-Benja-

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min & Jonides, 1986; Sanders et al., 1987, *re*: frequency of occurrence; cf. Naveh-Benjamin, 1987, *re*: spatial location; cf. Zacks et al., 1984, *re*: temporal order). More specifically, all of these studies have drawn attention to the retrieval stage, which may be processed effortfully.

Support for this claim was found in a study by Vakil, Blachstein, and Hoofien (1991), in which temporal order judgment was evaluated under intentional and incidental retrieval conditions. Their results showed that more criteria of innate automaticity were fulfilled under the incidental retrieval condition than under the intentional condition.

The purpose of the present study was to focus on the retrieval stage in the frequency judgment process by employing Schacter's (1987) distinction between implicit and explicit expressions of memory in which, by definition, the former requires unintentional retrieval while the latter requires intentional retrieval of the information. It is our hypothesis that, when memory is tested explicitly using an effortful task (i.e., word recall) or an automatic task (i.e., frequency judgment), the control group will show an advantage over the HI group. However, we expected that the number of word repetitions would have an identical effect on performance of the two groups when measured implicitly by the word-stem completion task, since completing the word does not require intentional retrieval.

METHOD

Subjects

Two groups of subjects participated in the present study: a control group (non-brain-damaged) and a head-injured (HI) group. The control group consisted of 15 volunteers ranging in age from 20 to 41 years (mean = 27); their education ranged from 11 to 15 (mean = 13) years of schooling. The HI group was composed of 14 patients ranging in age from 16 to 53 years (mean = 30); their education ranged from 8 to 15 (mean = 12) years of schooling. Table 1 provides a more detailed description of the patient group.

The HI patients were recruited for the study from among a population of patients admitted to the Loewenstein Hospital (Israel) for rehabilitation after a traumatic brain injury, following a car accident.

Stimuli

A list of 39 low-frequency Hebrew words (Balgure,

Table 1. Demographics of the Head-Injured Patient Group.

Patient	Age	Sex	H	Ed	TAO	COMA	GCS
TY	20	M	R	12	23	13-D	3
CY	19	M	R	12	10	4-D	7
NA	25	M	R	12	7	10-D	6
ZF	22	F	R	15	8	1-D	*
GB	53	M	R	12	39	7-D	*
CO	22	F	R	12	19	7-D	*
SA	52	F	R	8	4	5-H	14
NY	46	M	R	12	4	12-D	*
PS	19	F	R	12	5	7-D	7
TD	45	F	R	14	3	–	–
BE	19	M	R	12	59	115-D	4
CD	39	F	R	12	18	11-D	*
EE	16	M	R	10	25	10-D	7
KY	20	M	R	8	13	6-D	*

Ed = education (years); *H* = Handedness; *TAO* = time after onset (weeks); *COMA* = Length of coma, (*D* = in days, *H* = in hours); *GCS* = Glasgow Coma Scale, at admission to hospital; * = Information wasn't found on records.

1968) were used to construct a 60-item presentation list. The body of the list consisted of 18 target words. Twelve words were presented once, 3 words presented three times, and 3 words presented six times. These target words were randomly intermingled with the additional 15 words in the list that were used as fillers. In addition, the initial and final 3 words were used as fillers to counteract primacy and recency artifacts.

Testing procedure
In the acquisition phase, cards of 20cm X 20cm with one word in the center were presented to the subjects at the rate of one word per 3 s. Following the presentation, subjects were tested in three different ways: first, by *priming* – a word-stem completion task, in which the first two letters were given and they were asked to complete it with the first word that came to mind. In this task, the 18 target words of the list from the acquisition phase were used along with 18 new words; second, they were asked to *recall* as many words as possible; third, a *frequency judgment* task was given: 18 words constituting the body of the list were presented one at a time, in random order. Subjects were asked to estimate the number of times each word had been presented previously: once, three times, or six times.

RESULTS

The number of words presented at each frequency was not equal (i.e., 12 words appeared once, 3 words appeared three times and 3 words appeared six times). Scores of the first frequency on each task were, therefore, divided by four to maintain the correct proportion between frequencies and to allow for combined analyses with the other frequencies.

Recall Analysis
Figure 1 presents the proportional number of words recalled by each group as a function of the actual frequency of presentations.

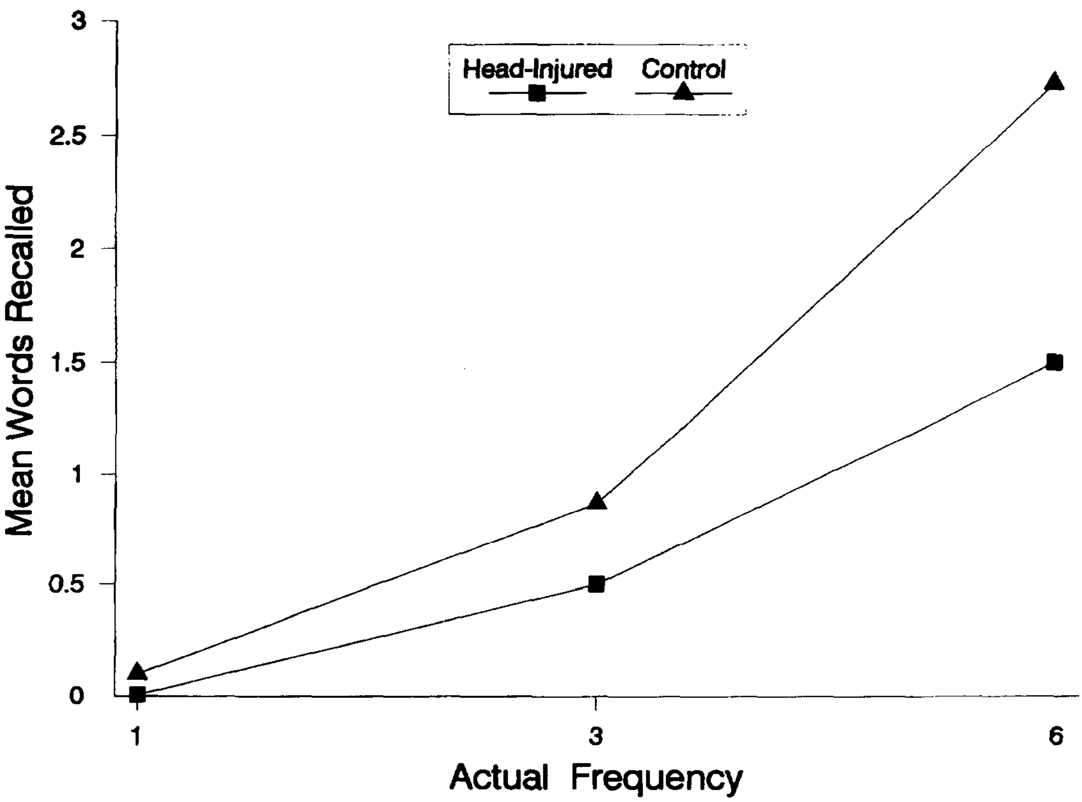

Fig. 1. The proportional number of words recalled by each group as a function of the actual frequency of presentations.

MANOVA was used to analyze the effect of group (HI and controls) by frequency (1, 3, and 6), the former being a between-subjects factor and the latter a within-subjects factor. Both main effects and the interaction between them were found to be significant: group ($F(1,27) = 13.52$, $p < .001$). Control was better than the HI group; frequency ($F(2,54) = 106.26$, $p < .001$). The higher the frequency, the more words were recalled: group by frequency ($F(2,54) = 8.42$, $p < .001$). Though recall of both groups was affected by frequency of presentation, the control group benefited more from the repetition of words.

Frequency Analysis

Two different scores were used (i.e., mean score and absolute deviation score) to evaluate performance on the frequency of occurrence task (for further discussion, see Tweedy & Vakil, 1988; Vakil, Galek, Soroker, Ring, & Gross, 1991).

Mean Score

This is the most widely used scoring method for frequency judgment, and was used in the original paper by Hasher and Zacks (1979). In this method, each subject contributes one score, which is the mean judgment value for every presentation frequency. For example, if the three words that appeared three times each were judged to appear once, three times, and six times, the average score would be very close to a perfect score, that is, 3.33. This illustrates the method's major problem, which is lack of sensitivity to the amount of variability in judgment at a particular frequency.

Figure 2 presents mean judged frequency as a function of the actual frequency for both control and HI groups.

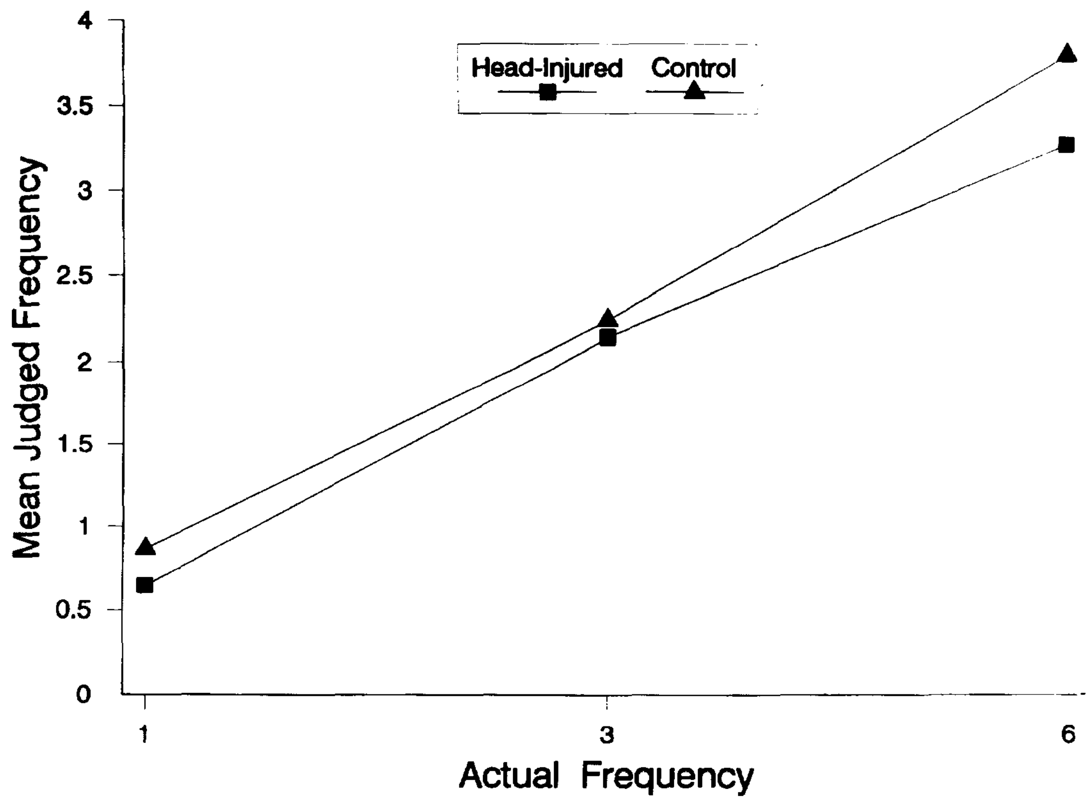

Fig. 2. The mean judged frequency as a function of the actual frequency for both control and HI groups.

MANOVA was used to analyze the effect of group (HI and controls) by frequency (1, 3, and 6), the former being a between-subjects factor and the latter a within-subjects factor. Frequency was the only significant main effect ($F(2,54) = 27.30$, $p < .001$). These results suggest that the groups did not differ from each other on overall mean judged frequency and that both groups showed the same rate of increment on mean judged frequency as a function of actual frequency. This increment is significant from one frequency to the other for both groups.

Absolute Deviation

In this scoring procedure the sum of the unsigned differences between each item's actual and judged frequency is computed, so that a perfect judgment will yield an absolute deviation score of zero. Using the above example the deviation score will be $|3-1|+|3-3|+|3-6|=5$, which is far from being a perfect score (i.e., zero). This example demonstrates that the deviation score better reflects the inaccuracy of frequency judgment. This scoring method has been used previously and found to be more sensitive than mean scores in detection of group differences (Tweedy & Vakil, 1988; Vakil et al., 1991).

Figure 3 presents absolute deviation scores as a function of the actual frequency for both control and HI groups. Note that because the score reflects deviation from the correct answer, the higher the score, the worse the performance.

MANOVA was used to analyze the effect of group (HI and controls) by frequency (1, 3, and 6), the former being a between-subjects factor and the latter a within-subjects factor. The main effect of group was significant ($F(1,27) = 17.20$, $p < .001$), with the control group having lower deviation scores than the HI group. The main effect of frequency was significant as well

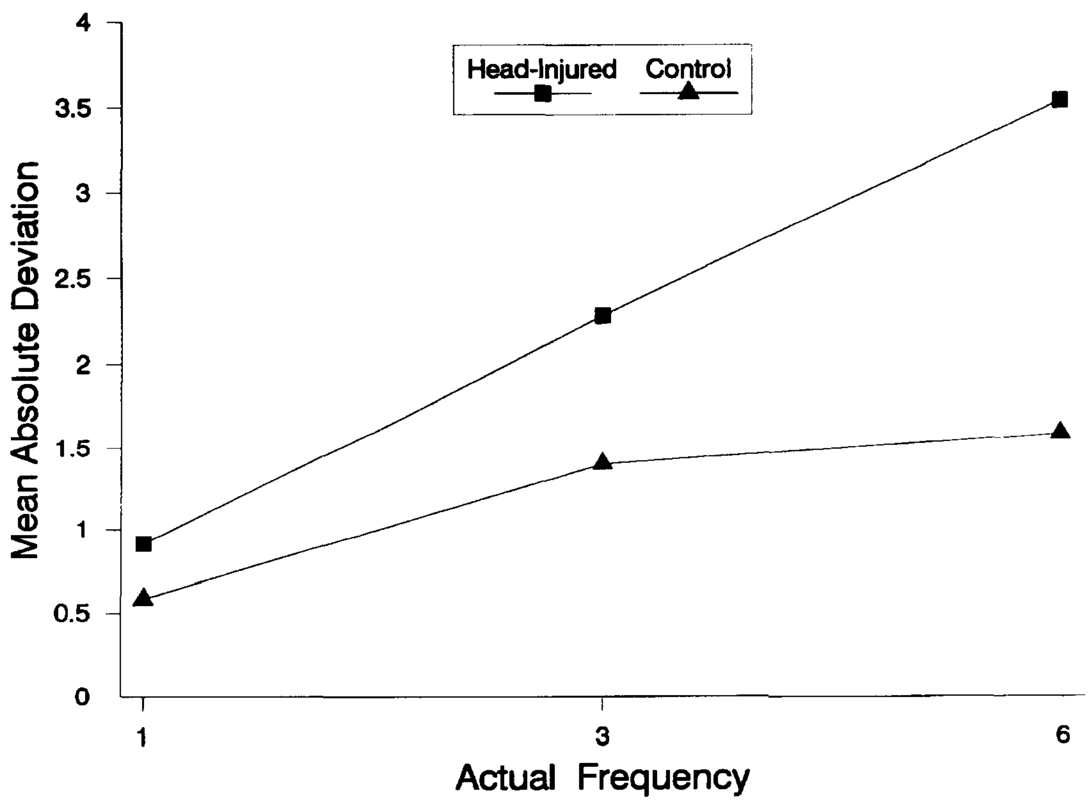

Fig. 3. Absolute deviation scores as a function of the actual frequency for both control and HI groups.

($F(2,54) = 24.62$, $p < .001$), the higher the frequency the higher the deviation scores. A significant group by frequency interaction was also obtained ($F(2,54) = 5\text{-}03$, $p < .01$). Accuracy in frequency judgment as reflected in the absolute deviation scores was affected by frequency of presentation. The higher the frequency the less accurate the performance. However, the increase in deviation scores with frequency was steeper in the HI group than in the control group.

Priming Analysis

Figure 4 presents the proportional number of words recalled under word-stem priming condition as a function of the actual frequency for both control and HI groups.

MANOVA was used to analyze the effect of group (HI and controls) by frequency (1, 3, and 6), the former being a between-subjects factor and the latter a within-subjects factor. Frequency was the only significant main effect ($F(2,54) = 34.77$, $p < .001$). These results suggest that the groups did not differ significantly on the correct word completion task. Moreover, both groups benefited similarly from the repetition of words. The increment in correct word completion was significant from one frequency to the other for both groups.

DISCUSSION

The major advantage of the paradigm used in this study is that it allows extraction of three different measures within the same task, each of which taps a different aspect of memory. Comparison of the HI and control groups on recall, frequency judgment, and priming enables us to make a within-task comparison, thus minimiz-

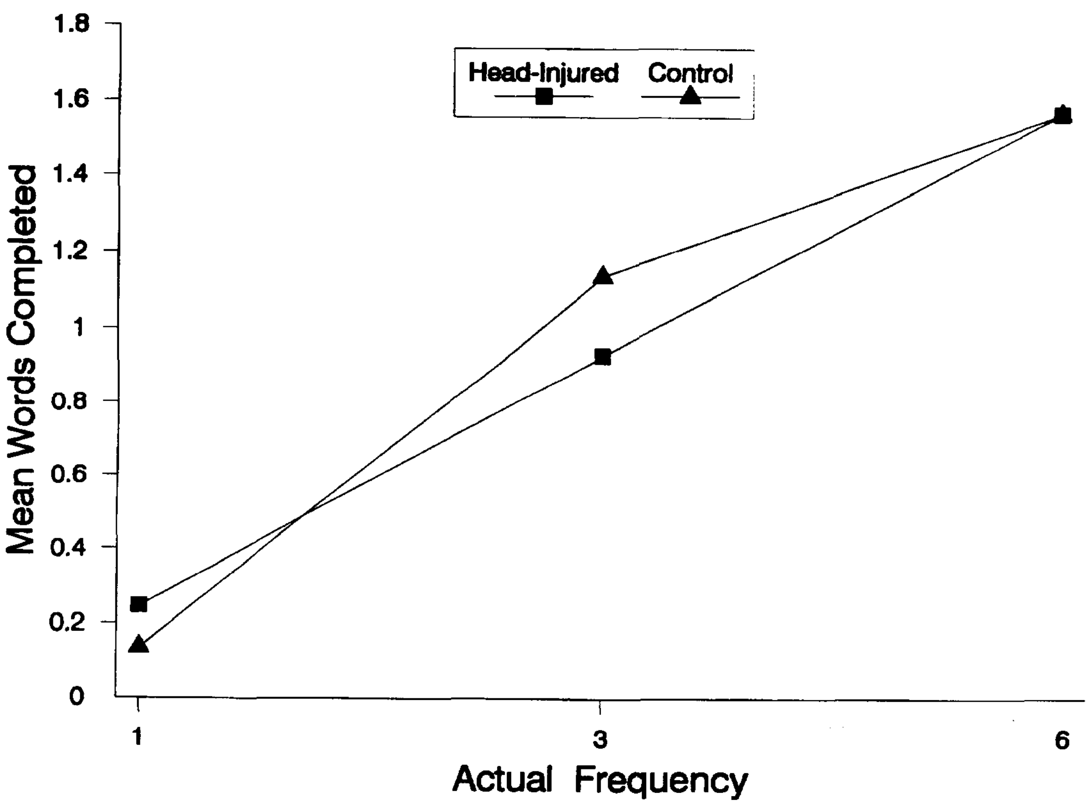

Fig. 4. The proportional number of words recalled under word-stem priming condition, as a function of the actual frequency for both control and HI groups.

ing uncontrolled artifacts which can occur in between-task comparisons.

As in previous findings (Levin, Goldstein, High, & Williams, 1988; Tweedy & Vakil, 1988), HI subjects were impaired in their word recall and in their frequency judgment. Furthermore, the finding that different scoring methods of frequency judgment can yield different results has also been reported previously (Tweedy & Vakil, 1988; Vakil et al., 1991). Since the mean score, unlike the absolute deviation score, does not take into account variability in the subjects' frequency judgment, it sometimes fails to detect group differences. Lack of group differences is interpreted as supporting Hasher and Zacks' (1979) argument that this task is processed automatically. For that reason, the results of this study are important, since they once again demonstrate that the differing findings depend on the scoring methods used. Despite the fact that mean scores are widely used, we recommend adopting the alternative method of absolute deviation scores, since it has repeatedly been proven to be a more sensitive scoring method.

Many studies have reported that priming (e.g., word-stem completion) is one of the preserved memory tasks found in amnesia (Graf, Squire, & Mandler, 1984; Shimamura, 1986). In this regard the present study makes a further contribution: Not only did the HI group fail to differ from the control group, but even more telling is the fact that both groups benefited *equally* from repetitions of the words when a priming test was used.

What do these results tell us regarding Hasher and Zacks' (1979) theory? The primary goal of this study was to evaluate frequency of occurrence implicitly by avoiding effortful-intentional retrieval. The motivation for this investigation is to control for the possibility raised by different researchers, as reviewed above, that while encoding of frequency might be automatic, retrieval might be effortful.

Both groups differed significantly on the explicit memory tasks (i.e., word recall and frequency judgment), but not on the implicit task (i.e., word-stem completion). This is interpreted to mean that the HI are as sensitive to word repetition – frequency of occurrence as the control group, but fail in the *intentional retrieval* of this information. Thus, in terms of Hasher and Zacks, it seems that frequency of occurrence is encoded automatically but is retrieved effortfully. This finding is in accordance with a previous study of Vakil, Blachstein, and Hoofien (1991) which found that HI patients were inferior to control subjects in their judgment of temporal order when intentional but not incidental retrieval measures were used.

In conclusion, this study illustrates the advantage of using paradigms that allow for analysis of the same information in different ways that seems to tap different memory processes.

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