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Latency and Duration of Visual Mental Images in Normal and Depressed Subjects

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Subjects were presented with nouns and required to form visual mental images in response to them. The generation latencies and durations of images, as indicated by subjects by pressing a key, were recorded. The results confirmed that the higher the noun imagery value, the shorter the generation latencies, but that imagery value does not affect image duration. This pattern was unchanged in two sessions held three weeks apart. Depressed subjects were also tested with the same task. These subjects failed to form many images, especially in response to low imagery nouns, but this effect was significantly reduced by antidepressant treatment. Generation latencies were significantly longer for depressed subjects than for controls. They were not affected by antidepressant treatment. The image durations in control and depressed subjects were of similar magnitudes. These findings are interpreted as indicating that functionally distinct processes are required for generating and maintaining visual images

Forming and inspecting visual mental images undoubtedly requires time (e.g., Cocude, 1988; Farah & Péronnet, 1989; Kosslyn, 1980; Paivio, 1986). Measuring the time required for imaging is an especially valuable part of imagery research because it provides information on the basic processes of image generation. The mental operations that people perform on their images (such as inspecting, transforming, rotating them, etc.) depend on these processes. Image generation is severely impaired by neurological lesions (e.g., Basso, Bisiach, & Luzzatti, 1980; Farah, Levine, & Calvanio, 1988; Goldenberg & Artner, 1991; Tippett, 1992). Hence, the

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processes involved in image generation under normal conditions need to be clearly understood.

Latency and Duration of Visual Images

Forming a mental image involves the temporary activation of representational units retrieved from long-term memory into a specialized processor, or "visual buffer" (Kosslyn, 1980). The representations transiently activated in the visual buffer are experienced by subjects as being structurally analogous to perceptual events, and they are accessible to conscious inspection, just as perceptual events are (cf. Denis, 1991; Denis & Cocude, 1989; Finke, 1989). Two main processes are assumed to take part in the forming and inspecting of an image. The first is *image generation*, in which a long-term representation in memory is recruited and activated to some critical extent. This process results in the creation of a transient pattern of activity in the visual buffer. The subjective counterpart of this activity is the experience of imagery, which is reported by the subject by an overt declaration. In operational terms, *image latency* is defined as the time that elapses between the presentation of some (usually verbal) stimulus to the subject and the subject's declaration that an image has been formed and is actually present in his or her mind.

Another period of interest in the processing of a visual image is the period during which the representational units in the visual buffer are activated above a critical value. During this period, the subject who has generated an image can testify that it is still present in his or her mind. Here the theory has to account for processes responsible for *image maintenance*. Kosslyn's (1980) theory posits that an image begins to decay as soon as it has been formed in the visual buffer, and that image-refreshing processes are used to maintain the level of activation of the image above a critical threshold. We define as *image duration* the time that elapses between the subject's declaration that an image has been formed and his or her declaration that the image is no longer available for conscious inspection.

The processes responsible for image generation and image maintenance, and their respective chronometric indicators, have been investigated in previous research. A number of experiments have attested to the value and consistency of responses from which image latencies are calculated, and they have identified the main factors that affect such measurements. Image generation has been shown to be easier (i.e., image latencies are consistently shorter) when verbal items with a high rated concreteness or imagery value are used as stimuli (e.g., Cocude & Denis, 1988; Morris & Reid, 1973; Paivio, 1966). Words denoting basic concepts elicit visual images more quickly than do more general or more specific words (Hoffmann, Denis, & Ziessler, 1983). More time is also usually required to generate a visual image as the number of elements in this image or its detail increase (Beech & Allport, 1978; Kosslyn, Reiser, Farah, & Fliegel, 1983; McGlynn & Gordon, 1973; McGlynn, Hofius, & Watulak, 1974; Paivio, 1975). Lastly, there is evidence that subjects classified as high visuo-spatial imagers have shorter image latencies than poor imagers (Cocude & Denis, 1988; Ernest & Paivio, 1971; Hoffmann, Denis, & Ziessler, 1983).

On the other hand, there has been much less experimental research on image duration. This may be due to the difficulty of defining the "end" of an image (cf. Cocude & Denis, 1988). In terms of the framework outlined above, cessation of an image should be the cessation of the cognitive activity that started when the subject declared that an image had been formed. However, an image probably decays gradually, so that is is difficult to determine a precise threshold of cessation. In addition, subjects' declarations may be based on different criteria. Kosslyn et al. (1983) tried to get around the difficulty of measuring the absolute durations of images by demonstrating lower availability of verification responses as the interval between subject's declaration that an image has been formed and the presentation of the verification question increased. In the two published studies on subjective estimates of image duration (Cocude & Denis, 1986, 1988), the definition of image cessation that subjects were instructed to adopt was the moment when the image just formed was no longer present in their mind or underwent any internal modification. The results showed that word imagery value had no systematic effect on image duration (in contrast with its effect on image latency). This suggests that images elicited by words with high or low imagery values have no differential characteristics likely to affect their maintenance. Furthermore, high imagers do not maintain images longer than poor imagers (although the image latencies of the former are shorter than those of the latter) (Cocude & Denis, 1988). Cocude and Denis (1986) investigated a group of subjects expected to have special capacities for maintaining their images. Subjects who were familiar with mental concentration techniques, such as hatha yoga, did have significantly longer image durations than control subjects (although they did not generate images any faster).

Some factors that are likely to affect the latency or duration of images have been identified. More importantly, empirical findings have also helped to refine our theoretical view of mental imagery as a multicomponent process. It is now widely accepted that mental imagery is not a global, undifferentiated cognitive capacity, but rather a set of differentiated processes, which are to some extent independent of each other (e.g., Kosslyn, Brunn, Cave, & Wallach, 1984; Poltrock & Brown, 1984). As regards image formation, Kosslyn's (1980) theory postulates a two-step mechanism in line with the distinction proposed above between generation and maintenance of images. This view is in contrast with the alternate assumption that a single process is responsible for both generating and maintaining images in the visual buffer. More recent writings by Kosslyn (1994) seem to favor this single-process hypothesis. However, a single process for image generation and maintenance is not compatible with the data indicating distinct processes. In particular, there is no indication that the factors which affect latencies have any effect on durations (this is true of word imagery value, on the stimulus side, and of individual imagery capacities, on the subject side). On the other hand, at least one factor that strongly affects image duration (mental concentration techniques) has no effect on image latency. This pattern of results (Cocude & Denis, 1986, 1988) is consistent with the hypothesis that the processes responsible for image generation are distinct from those responsible for image maintenance.

Mental Imagery in Depressed People

The research reported here was first designed to clarify the issue of whether processes responsible for generation and maintenance of images should be considered as differentiated from each other. The variables which were entered as factors in the experiment were examined in terms of their converging or contrasted effects on image latencies and durations. This study also extends research on chronometric characteristics of imagery to a group of subjects likely to show particular response patterns. The only other study on specific populations of subjects was devoted to experts in mental concentration (Cocude & Denis, 1986). These subjects did not generate images any faster than the control subjects, but they were capable of retaining their images for almost twice as long. This effect was interpreted as reflecting the subjects' special capacity to provide their images with steady activation, and also to protect themselves from distracting external stimuli.

Our main concern in the present research is the subjects who, in contrast, may have altered image processing because they are in a psychological state that is likely to depress their cognitive capacities. A variety of cognitive alterations during episodes of depression have been reported (e.g., Cohen, Weingartner, Smallberg, Pickar, & Murphy, 1982; Norman, Miller, & Keitner, 1987; Pierson, Partiot, Ammar, Dodin, Loas, Jouvent, & Renault, 1991; Strömgren, 1977). According to Tancer, Brown, Evans, Ekstrom, Haggerty, Pedersen, & Golden (1990), these alterations are seen in tasks requiring great cognitive effort, whereas the performance of depressed people is not decreased in tasks with low cognitive cost. Bulbena and Berrios (1993) emphasized the transient character of these perturbations, which are reversible in most subjects.

Our study examined subjects suffering from depression rather than other forms of mental illness for several reasons. Firstly, the cognitive deficits associated with depressive syndromes are well documented. Second, depression is known to slow cognitive mechanisms, which is especially relevant in the domain of imagery where timing is of primary importance. Third, depression is a form of illness which can be modified by appropriate medication. It would be interesting to know whether the performance of an imagery task in an acute phase of depression is different from that of the same subjects after treatment. Finally, there is another way of considering depression in relation to mental imagery. Imagery has been reported to be a useful therapeutic aid for reducing or controlling depression (cf. Abraham, Neundorfer, & Terros, 1993; Gold, Jarvinen, & Teague, 1982; Hart & Means, 1985; Jarvinen & Gold, 1981). Thus, a better knowledge of the imagery capacities of depressed people is required before recommending any therapy grounded on this cognitive process in the treatment of depressive symptoms.

Because people suffering from depression respond more slowly in most cognitive tasks, we postulated that they would have longer image latencies than control subjects. The prediction is less straightforward for image duration. Because maintaining an image in the visual buffer is assumed to involve some amount of cognitive resources, depressed subjects' limited processing resources may well tend to shorten the duration of their images. But this prediction implicitly assumes that the cognitive costs of generating and refreshing images are of comparable magnitudes. Although no direct tests are available on this issue, most of the findings reported above suggest that image generation is more resource demanding than is image refreshing. More resources are required for image generation because it involves searching for a representation in long-term memory, transfering it in the visual buffer, and applying activating processes in order to generate the image. The processes involved in refreshing the image only require maintenance of an already implemented, ongoing activation. Consequently, we predicted that depressed people would probably have longer image latencies than controls, but similar (or moderately decreased) image durations.

Such a pattern would lend support to the view that generation and maintenance are controlled by distinct processes. If depressed people had longer latencies and shorter durations than controls, it might indicate that the generation and maintenance of images involve the same process. If, on the other hand, both generation and maintenance show distinct patterns when the same variable is introduced, this would support the alternate view of different sets of processes, as both would be affected differently by the new variable.

The last concern was about the reversibility of the chronometric pattern in depressed people after treatment. Although this work was not aimed at evaluating the effectiveness of treatments as such, subjects were tested during a depressive episode and about three weeks later, when they were supposed to be in (at least partial) relief. This study of depressed people required a group of control subjects who were examined under the same conditions (two tests three weeks apart). This control part of the experiment was also expected to provide information on an issue which has remained mostly unexplored, that is, how consistent normal subjects' responses are in imagery tasks. Morris and Reid (1973) reported that subjects who were presented with the same imagery task twice showed no change in the latency of image formation to high imagery words, but the latency for low imagery words decreased on the second presentation. The same image also recurred less frequently in response to low imagery words. But the two tasks were executed in the same session in Morris and Reid's (1973) experiment. We have, therefore, collected data which should provide information on how consistent subjects are when they are examined after a rather long interval, both for latencies and durations.

Method

Subjects

The subjects were all adult French native speakers, aged 19-67 years, who volunteered to participate in the experiment. The control group contained 16 subjects (6 men, 10 women, mean age: 37.3) without any psychiatric history, who were working at the hospital where the patients were treated. The experimental group comprised 16 adult inpatients (10 men, 6 women, mean age: 48.9) suffering from depression according to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 1994) diagnostic criteria of major depression without psychotic characteristics. Exclusion criteria were organic mental disorders, schizophrenia, and abuse or dependence on alcohol or other substances. Personality disorders were not exclusion criteria. The control and experimental groups were matched for socio-economic status and education. In particular, both groups had similar number of years of secondary education.

The subjects in the experimental group were rather severely depressed according to the Montgomery-Asberg Depression Rating Scale (MADRS; Montgomery & Asberg, 1979), with scores above 25 on the scale. The degree of slowing down of mental processes was rated with the Salpêtrière Retardation Rating Scale (SRRS; Widlöcher, 1983). The patients were given antidepressant treatment (tricyclics or selective serotonine reuptake inhibitors), usually with an anxiolytic (benzodiazepines). This medication had been given for a few days before the first session, so that a steady state was obtained that was without any effect on the depression. The patients were still on the same treatment when they participated in the second session. The treatment had improved their depression symptoms. This improvement was evaluated using the MADRS and the SRRS again. The average MADRS scores dropped from 31.06 ($SD = 4.55$) in the first test to 9.7 ($SD = 1.40$) in the second, and the average SRRS scores dropped from 30.12 ($SD = 4.50$) to 11.87 ($SD = 2.47$). The decreases were significant, $t\,(15) = 17.3$, $p < .001$, and $t\,(15) = 18.65$, $p < .001$, respectively.

Materials

The words used in the experiment were 36 two-syllable French nouns selected from a pool of nouns which had been previously rated for imagery value on a 7-point scale, from 0 (no image) to 6 (clear, vivid image), and for emotional value on a scale from -3 (very unpleasant emotion) to +3 (very pleasant emotion) (cf. Cocude, 1988). The 36 nouns selected had neutral emotional values (mean = 0.14, $SD = 0.45$). They were grouped in three categories: 12 high-imagery (HI) nouns, whose imagery values ranged from 5.01 to 5.56 (mean = 5.19, $SD = 0.16$); 12 medium-imagery (MI) nouns, whose imagery values ranged from 3.04 to 4.39 (mean = 3.73, $SD = 0.48$); and 12 low-imagery (LI) nouns, whose imagery values ranged from 1.16 to 2.74 (mean = 1.99, $SD = 0.40$). The whole set of nouns was divided into two equivalent lists, A and B, each including 6 nouns of each imagery category. Table 1 shows the nouns in Lists A and B. The mean imagery values and emotional values of HI, MI, and LI nouns in both sets of items are shown in Table 1. The similar numerical values in both sets indicate the equivalence of Lists A and B.

There were two versions of each list, A and B. In one version, the sequence of the 18 nouns was random, with the only constraint being that there be no more than two nouns of the same imagery-value level in succession. The other version followed the reverse sequence, with the first item being the last item of the previous version, and vice versa.

Table 1
Nouns Used as Stimuli

List A		
	Imagery Value	Emotional Value
High Imagery		
Armoire (Cupboard)	5.06	+0.43
Chapeau (Hat)	5.10	-0.10
Chemise (Shirt)	5.13	+0.50
Journal (Newspaper)	5.23	+0.53
Mouchoir (Handkerchief)	5.06	-0.20
Oreille (Ear)	5.56	+0.50
Mean Value	5.19	+0.28
Medium Imagery		
Commerce (Trade)	3.32	-0.10
Croquis (Sketch)	3.31	+0.43
Distance (Distance)	3.30	-0.63
Géant (Giant)	4.10	-0.37
Peuple (People)	3.40	+0.40
Sculpteur (Sculptor)	4.29	+0.70
Mean Value	3.62	+0.07
Low Imagery		
Année (Year)	2.74	+0.03
Instant (Instant)	2.00	+0.83
Logique (Logic)	2.36	+0.53
Notion (Notion)	1.16	+0.10
Prudence (Caution)	2.00	+0.30
Système (System)	1.70	-0.72
Mean Value	1.99	+0.18

List B		
	Imagery Value	Emotional Value
High Imagery		
Canard (Duck)	5.26	+0.83
Ceinture (Belt)	5.01	-0.33
Menton (Chin)	5.36	+0.17
Moustache (Moustache)	5.07	0.00
Soulier (Shoe)	5.27	+0.47
Tapis (Carpet)	5.17	+0.50
Mean Value	5.19	+0.27
Medium Imagery		
Agence (Agency)	3.71	-0.43
Congrès (Congress)	3.04	-0.37
Eclipse (Eclipse)	3.50	+0.03
Empreinte (Imprint)	4.10	-0.13
Gravure (Engraving)	4.39	+0.80
Plombier (Plumber)	4.30	-0.26
Mean Value	3.84	-0.06

	Imagery Value	Emotional Value
Low Imagery		
Epoque (Epoch)	2.26	+0.13
Fonction (Function)	2.03	+0.10
Méthode (Method)	2.26	+0.23
Moment (Moment)	1.90	+0.43
Principe (Principle)	1.63	-0.90
Synthèse (Synthesis)	1.80	+0.53
Mean Value	1.98	+0.09

Procedure

Subjects were tested individually in a quiet room in a two-session procedure, with each subject being tested twice on the same imagery task (with two parallel versions of the material). In the first session, subjects were given appropriate instructions on a 5-minute audiotape. The subjects were told that they would have to listen to a list of nouns and form as clear and accurate a visual image as possible after hearing each noun. They had to indicate, by pressing a key (response 1), the moment when the image had been formed, and then, by pressing the key again (response 2), the moment when the image disappeared or was in some way modified. Subjects were asked to give a brief description of each image before the presentation of the next noun. No instructions were given as to whether subjects should keep their eyes open or closed during the experiment, and they were not instructed to make any special effort to maintain their images. The instructions were followed by four demonstration items. The imagery task then started with two practice items (which were not taken into account in the data analysis) followed by the 18 stimulus nouns. Half of the subjects were given List A and the other half List B (following the original random sequencing in both cases). After the imagery task, the subjects were invited to provide self-ratings on the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983).

The second session took place 20-24 days after the first session, depending on the subjects' availability (average interval: 22 days). The session used the same imagery task as in the first session, following exactly the same procedure. Subjects who had first received List A were presented with List B, and vice versa (both reversing the original random sequencing). After the imagery task, all subjects were invited to complete an imagery questionnaire and a visuo-spatial test. The questionnaire was the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), which provides self-rated measures of the vividness of visual imagery for 16 items. In the French version of the VVIQ, higher scores indicate more vivid imagery (cf. Denis, 1995). The test was a shortened version of the Minnesota Paper Form Board (MPFB; Likert & Quasha, 1941), which provides measures of visuo-spatial abilities in a time-limited task involving the mental assemblage of geometric elements. Lastly, subjects in the experimental group completed the HADS questionnaire, as they did in the first session.

Results and Discussion

The control subjects' self-ratings of anxiety and depression on the HADS resulted in an average score of 10.12 ($SD = 4.10$), which is below the pathological threshold (11). The depressed subjects' self-ratings at the first session resulted in an average score of 26.97 ($SD = 4.88$), which was significantly above the average score of control subjects, $t(30) = 11.47$, $p < .001$ (two-sided test). The depressed subjects' average score at the second session was 17.31 ($SD = 8.07$), which was significantly reduced from the first session, $t(15) = 4.90$, $p < .001$ (two-sided test), although well above the pathological threshold.

The control subjects' VVIQ scores were slightly higher than those of depressed subjects, 45.56 ($SD = 9.78$) vs. 40.94 ($SD = 8.72$), respectively, but this difference was not significant. The MPFB scores were significantly higher for control than for depressed subjects, 16.75 ($SD = 4.54$) vs. 13.00 ($SD = 4.90$), respectively, $t(30) = 2.25$, $p < .05$ (two-sided test). This is not surprising, given the high attentional cost of this test. Even after the treatment had its first effects, the depressed subjects remained less efficient than controls on the MPFB.

Mean image latencies and durations were calculated for each category of nouns, for each subject. Some particular problems arose in the group of depressed subjects, especially during the first session, when they were the most severely depressed. Some of them produced no image in response to nouns (they declared that they were not able to visualize the designated concepts), or had exceptionally long image latencies. The following procedure was used when analyzing the data for both groups of subjects. Extreme latencies (more than 2 standard deviations from the mean of a given subject for a given category of nouns) were eliminated and replaced by the largest of the remaining values. The same procedure was used to replace missing values resulting from the fact that subjects were unable to form any image in response to a particular noun. In the few cases where a value was missing for some technical reason, it was replaced by the mean of the remaining values for the same category of nouns. For image durations, extreme values and missing values were replaced by the subject's mean for the corresponding category of nouns. Overall, the values which had to be replaced because of the subjects' extremely late response or absence of any response accounted for only

0.3% of the whole set of data for the control group, and 7.8% for the depressed group.

Control Subjects

Virtually all control subjects reported forming an image for all nouns presented. Proportions of reported images at the first session were 100% in response to HI nouns, 99.0% to MI nouns, and 100% to LI nouns. At the second session, corresponding proportions were 100%, 100%, and 99.0%, respectively.

Table 2 shows mean image latencies and durations for the three categories of nouns, at both sessions. Analysis of variance showed a significant effect of noun imagery value on latency, $F(2, 30) = 56.99$, $p < .001$. Partial comparisons revealed that latencies were shorter for HI than for MI nouns, $F(1, 15) = 22.37$, $p < .001$, and that the latencies for these two categories taken together were shorter than those for LI nouns, $F(1, 15) = 58.61$, $p < .001$. There were no difference between latencies in the two sessions.

Table 2
Mean Image Latencies and Durations in Seconds (Control Subjects)

	Noun Imagery Value		
	High	Medium	Low
Latencies			
Session 1	2.61	3.16	6.43
Session 2	2.56	3.12	6.45
Durations			
Session 1	8.72	9.25	8.46
Session 2	9.43	10.55	10.05

Mean image latencies recorded in this experiment were very similar to those of Cocude and Denis (1988). More generally, the findings are consistent with previous reports showing that the higher the imagery value of stimulus nouns, the shorter the time required to generate visual images (cf. Morris & Reid, 1973; Paivio, 1966). The present experiment also showed the great consistency of responses when the same subjects were tested on two parallel versions of the imagery task with a 3-week interval between tests.

The analysis of image durations revealed no systematic effect of noun imagery value on times, and there was no difference in image durations from session to session. This again confirms the data reported by Cocude and Denis (1988), the numerical values of which were similar to those shown in Table 2. It, therefore, seems that the time during which an image can be held in the mind is not correlated with the cognitive difficulty associated with constructing the image. Lastly, durations remained approximately unchanged from session to session. The stability of chronometric indicators of imagery was thus verified for both image latency and image duration.

A further attempt was made to reveal any correlation between latencies and durations that might have been masked by the averaging procedures used above. The average image latency and image duration were calculated for each noun in the experiment. Considering the whole set of 36 nouns used, the correlation coefficient between latencies and durations was $r(34) = -.08$.

Depressed Subjects

The proportions of images that subjects reported having formed at the first session were 97.9% in response to HI nouns, 96.9% to MI nouns, and 71.9% to LI nouns. This clearly shows the special difficulty depressed subjects had in forming images in response to the less imageable nouns. The corresponding proportions at the second session were 97.9%, 97.9%, and 89.6%, respectively. The improvement in subjects' capacities to form images was mostly for the LI nouns. Comparing the number of images formed in response to LI nouns in both sessions indicated a significant increase, $t(15) = 2.25$, $p < .05$ (two-sided test).

The mean image latencies and durations of depressed subjects are shown in Table 3. Analysis of variance of image latencies revealed a significant main effect of noun imagery, $F(2, 30) = 44.87$, $p < .001$. The latencies were shorter for HI than for MI nouns, $F(1, 15) = 8.66$, $p < .025$, and these two noun categories taken together had shorter latencies than LI nouns, $F(1, 15) = 58.29$, $p < .001$. There was no difference between the latencies in the two sessions.

Table 3
Mean Image Latencies and Durations in Seconds (Depressed Subjects)

	Noun Imagery Value		
	High	Medium	Low
Latencies			
Session 1	4.43	5.47	8.40
Session 2	4.87	5.51	7.94
Durations			
Session 1	8.24	8.27	8.45
Session 2	7.60	8.37	8.85

An analysis combining the data of control and depressed subjects revealed that latencies were consistently longer for depressed than control subjects, $F(1, 30) = 9.29$, $p < .005$. This effect was quite similar in magnitude for both sessions and for all noun categories. No interaction was significant.

Three main pieces of information are provided by these analyses. Firstly, depressed subjects were slower in their imagery responses than control subjects. Second, this effect was not qualified by the category of nouns used as stimuli, since the patterns of the effects of noun imagery value were very similar for both groups of subjects. Third, there was no sign of any improvement in the generation latencies when depressed subjects had been treated (at least, within the interval considered in this study).

Analysis of image durations did not reveal any effect of noun imagery value, and there was no reliable change in durations between the first and second sessions. The analysis combining the data of control and depressed subjects revealed that durations were quite similar in both groups of subjects, without any interaction with the other sources of variation.

To summarize, depressed subjects did not differ from controls as concerns image duration. The absolute values in both groups were quite similar. Furthermore, image durations in the depressed subjects, as in the controls, were not influenced by noun imagery. This pattern of results indicates that the cognitive cost of maintaining images is not correlated with the cost of their generation. As a further control, the correlation coefficient between latencies and durations for the whole set of 36 nouns was calculated. It was found to be non-significant, $r(34) = .25$.

Finally, we examined the possibility that age may have an effect on imagery responses. The depressed subjects were, on the average, older than controls. There is no strong published evidence that age has a major effect on imagery generation over the range of ages of our subjects. According to Dror and Kosslyn (1994), generation processes are significantly slowed only for subjects about 60 years old. Comparison of the younger and the older halves of the control group in our experiment showed no significant effect of age on image latency, or on image duration. It is thus unlikely that age contributes to the significant effect of depression on image generation in our experiment.

Conclusions

The results of this experiment confirm that image latencies are increased when nouns with lower imagery values are used as stimuli, and that image duration is not affected by the noun imagery value. The results were well reproduced when the experiment was repeated with the same subjects after a rather long interval (three weeks). Testing depressed subjects revealed that a many items elicited no image, but the number of these items decreased notably at the second test (after antidepressant treatment). The effect of noun imagery value on latency and the lack of its effect on duration were also found with the depressed subjects, but both latencies and durations were unaffected by treatment. The most remarkable difference between controls and depressed subjects was the difference in latencies, which were consistently longer in depressed subjects than in controls. On the other hand, image duration did not appear to be affected by depression.

Because image generation and image maintenance were affected differently by the factors manipulated in the experiment, our results provide further support for the assumption that these processes are functionally distinct from each other (cf. Cocude & Denis, 1988). Generation processes are believed to be responsible for accessing representational units in long-term memory and activating them in the visual buffer. After such activation, another set of processes takes over to maintain activation above a critical threshold. The maintenance of image activation depends on the amount of cognitive resources available for refreshing the visual image.

The most important effect of depression on imagery processes appears to concern generation. The effect is robust, and it was not influenced by the antidepressant treatment undergone by the patients. There were clear signs of increased performance in the most difficult part of the task, since many more images were generated in response to low imagery nouns after treatment. However, the analysis of generation latencies did not reveal any evidence that controls outperform depressed people especially in the most effort-demanding tasks, since the latencies of depressed subjects were consistently longer than those of normal subjects for all subsets of the material.

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