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Differences in vividness ratings of perceived and imagined patterns

Fiorella Giusberti*

Department of Psychology, viale Berti Pichat 5, 40127 Bologna, Italy

Cesare Cornoldi and **Rossana De Beni**

Department of Psychology, University of Padova

Manfredo Massironi

Institute of Psychology, University of Verona

The present research focuses on the different subjective experiences evoked by perceived and imagined matrices of letters of the alphabet. In three experiments adult subjects were asked to rate the vividness of a letter included in a matrix of letters which varied due to manipulations in colour, rotation and movement. Subjects were asked to observe (perceptual modality), draw and observe (drawing modality), retrieve (memory modality) or imagine (imagery modality) the matrices. For some manipulations of the critical letter (in particular, 45 degrees inclination and high contrast colour), the perceptual modality produced comparatively higher vividness ratings than the other two modalities. The perceptual effect of inclination was also duplicated with the memory modality group.

It is argued that different visual processes, either immediate and pre-attentive, or sequential and attentive, may be operating under voluntary control. Although visual imagery varies in some ways from immediate visual perception, the similarities found, between the drawing and imagery modalities, on the one hand, and the perceptual and memory modalities, on the other hand, suggest that they share some common underlying processes.

Experimental research on visual imagery has focused specifically on its functional properties, the main purpose being to demonstrate its actual existence and characteristics. In the debate between researchers supporting or denying the existence of specific visual imagery representations, one main criterion is the possibility of showing that visual imagery may function in an 'analogic' way, i.e. like visual perception. Nevertheless, the 'analogy' assumption has been applied in various ways (see also Intons-Peterson & McDaniel, 1990) and with differing degrees of stringency, i.e. images are either assumed to have identical properties to perceived

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objects or properties that are at least similar to those of perceived objects which are not present in other forms of symbolic representation. An impressive amount of data has been collected by many authors demonstrating that in many tasks (mental comparisons, mental rotation, mental scanning, etc.), patterns of response are similar when objects are perceived and when they are represented in the mind (e.g. Finke, 1985; Intons-Peterson & McDaniel, 1990). It is argued that these results are due to the imagery processes involved in the mental tasks being similar to visual processes.

In a recent review of research on the relationship between visual perception and visual imagery, Intons-Peterson & McDaniel (1990) noted that, although this relationship may be considered a close one, the numerous cases in which the similarities are only partial require more cautious investigations. In particular, the authors argued that mental images may be the result of the interaction between visual representation and subjects' knowledge, so that images are 'knowledge-weighted'.

Images can be analysed not only in relation to their functional properties, but also with respect to their structural properties, which emerge from phenomenological consideration of people's varying subjective experiences. This perspective is not particularly popular, probably due to the criticism that subjective experiences may be simple epiphenomena due to our conceptualizations of our own experiences. In our opinion, this criticism has many counter-arguments some of which go back to epistemological reflection on the roots of psychological inquiry. We will merely observe here that subjective imagery experience is so central and pervasive in our mental lives that its direct consideration is justified. Further, from this point of view, theoretical reflection on properties of images may move from ontological debate (given that the existence of images is self-evident) to a better-defined consideration of their subjective qualities. Without any ontological preoccupation, research can examine, in particular, the relationship between perception and imagery, although the inability to find such a relationship may not necessarily support a radical denial of the existence of visual imagery.

The present research is devoted to comparing conditions in which perceptual and imagery experiences are similar with conditions in which they diverge. For this purpose, we looked for those characteristics which make perceptual activity specific and singular starting from Neisser's (1967) differentiation between perceptual processes which are 'pre-attentive', automatic, parallel and high speed, and slower perceptual processes which are serial, under voluntary control and suffer from capacity limitations. Neisser argues that pre-attentive processing segregates the perceptual field into units (objects) which are later more subtly analysed by attentive processes.

Analysis of pre-attentive visual processes has since been the subject of much visual perception research based on a variety of theoretical reflections (Dodwell, 1975; Fodor, 1983; Jackendoff, 1983; Kanizsa, 1979) and empirical methodologies. In particular, by using the reaction-time paradigm, some researchers have studied the characteristics which accelerate or delay the recognition of a target stimulus among other similar stimuli (e.g. Treisman, 1986). Others have tried to isolate factors which facilitate or inhibit the perceptual formation of stimulus groupings within larger figural contexts (e.g. Julesz, 1975). Treisman (1986) summarized this line of research by observing that only a limited number of characteristics, such as colour, size,

contrast, inclination, curvature and extremities of lines, are extracted during the first visual processing phases. These characteristics have been examined in a few studies, in different ways. In particular, Beck (Beck, Prazdny & Rosenfeld, 1983, p. 8) stressed that, in groupings of identical letters (like 'U' or 'L'), perceptual field segmentation is easier when some letters are rotated in the picture plane by 45 degrees (inclined) than when they are rotated in the picture plane by 180 degrees (reversed), taking on the aspect of an upside-down figure.

In our opinion, consideration of these characteristics is critical in the study of the relationship between visual perception and visual imagery. Like Neisser (1967), we believe that visual imagery is an attentional state which is slow, voluntary and constructive and, although not comparable to pre-attentive visual perceptual processes, it is similar to other slower successive visual processes. Therefore, conditions which are particularly critical only in the first phases of visual processing are not equally critical in visual imagery. The present paper examines the role of three such conditions which are easy to manipulate in a visual perception vs. visual imagery comparison study, i.e. rotation, colour contrast and movement.

To study rotation, we considered the different effects of letters rotated by either 45 or 180 degrees. To study colour contrast, we created a high-contrast condition (a green letter reproduced in a matrix of red letters) and a low-contrast condition (one pink letter in a matrix of red letters). To study movement, we had one condition in which a letter moved along a row of a matrix of letters and a second condition in which the same letter was stationary. For each pair of conditions, one condition (45 degrees rotation, high colour contrast, movement) provided a characteristic experienced in pre-attentive visual processing where, under some conditions, the 'pop-out effect' (Treisman & Souther, 1985) appears – an effect which produces the emergence of a target stimulus between other similar distractor stimuli. In our opinion, this effect not only determines more rapid recognition of the target stimulus but also affects subjective experience by producing a more evident phenomenological experience of the target stimulus. This can be contrasted with the response activated at the level of visual imagery.

In the present research, we used a 4×4 matrix of identical alphabet letters, in which one particular letter (in the 2.2 position) could assume different characteristics depending on the manipulated conditions of rotation, colour contrast and movement. We decided to use letters rather than other stimuli because they are easier to describe to subjects using the imagery modality. Subjects were asked either to observe or to imagine different matrices and to rate the phenomenological quality of the critical letter in the 2.2 position with respect to the overall matrix, giving vividness ratings. Choice of the 'vividness' dimension was due to the theory that, since Galton's (1883) pioneering research, this dimension has played a critical role in the study of image qualities. People do not seem to have problems in understanding a vividness rating requirement, so that vividness ratings are used both for differentiating between stimuli properties and between subjects' imagery abilities (Marks, 1972). As the vividness experience is self-evident, making it comparable to other, third-order, qualities of phenomenological experience (Metzger, 1941–1963), a long explanation of its meaning was not given: we limited ourselves to referring, if necessary, to the classical definition of vividness based on luminosity and clarity.

The vividness quality of phenomenological experience appears to be more greatly considered in imagined than in perceptual experience, in which the closest and most common correlation is probably found with the 'evidence' dimension. Nevertheless, after some pilot experiments, we found that in the perceptual modality subjects were able to rate the vividness of objects with no particular problems. We assumed that vividness ratings generally had to be higher in the perceptual modality, in which the matrix was physically present in front of the subject, but that this superiority would be particularly clear for the conditions capable of producing a pop-out effect (called 'favourable to perception'). We further hypothesized that between the conditions which were 'not-favourable to perception' vividness ratings would show significant differences, the low-contrast colour condition being less capable of giving prominence to the critical letter than the reversed-letter condition. It was predicted that prominence would be particularly reduced in the static no-movement condition in which the critical letter was identical in all respects to the other letters, so that this condition was not only compared to the movement condition (Expt 1) but was also considered as baseline (Expts 1 and 2), to be compared with all other conditions. This approach was also made necessary by the fact that our complete randomization design excluded the basic static condition for each letter, which occurred before the other conditions, in order to make clear to the imagery-modality subjects which matrix was to be processed and represented. Lastly, as some researchers (e.g. Sheehan, 1967) report that women give higher vividness ratings than men, we decided whenever possible to consider gender as an independent factor.

In our research, where visual perceptual modality was concerned, the main purpose was to examine whether the conditions favourable for perception produced vividness ratings which were significantly higher than in the visual imagery modality. The main purpose of Expt 2 was to verify whether such differences could be attributed to the pre-attentive characteristics of visual perception (different from the attentive constructive characteristics of visual imagery) and whether they could be eliminated by also asking for perceptual judgements after sustained attentive activity on the matrices. Lastly, in comparison with Expt 2, Expt 3 had a distinct purpose: while Expt 2 aimed at studying whether under some experimental conditions visual perception judgements are similar to judgements of visual imagery, Expt 3 examined whether by eliminating certain processes of visual imagery, judgements on the properties of a remembered image based on a recent perceptual exposure were similar to judgements given in the perceptual modality. Our main hypotheses were that, under some conditions, visual perception and visual imagery are different and that this difference is related to some underlying processes used in each case.

EXPERIMENT 1
Method

Subjects

Thirty-two adults, aged between 15 and 48, 16 males and 16 females, were divided into two groups (perceptual vs. imagery modality) and matched for gender, age and level of instruction.

Material

A capital letter was reproduced 16 times, in the centre of a white A4-format card, in such a way as to reproduce a 4 × 4 matrix. The size of the letters was 2.0 × 2.0 cm, their thickness was 2.5 mm, and the distance between letters 8 mm, both vertically and horizontally. The following six letters were used for the experimental task: F, L, Q, R, T, U. Examples of the matrices are shown in Fig. 1.

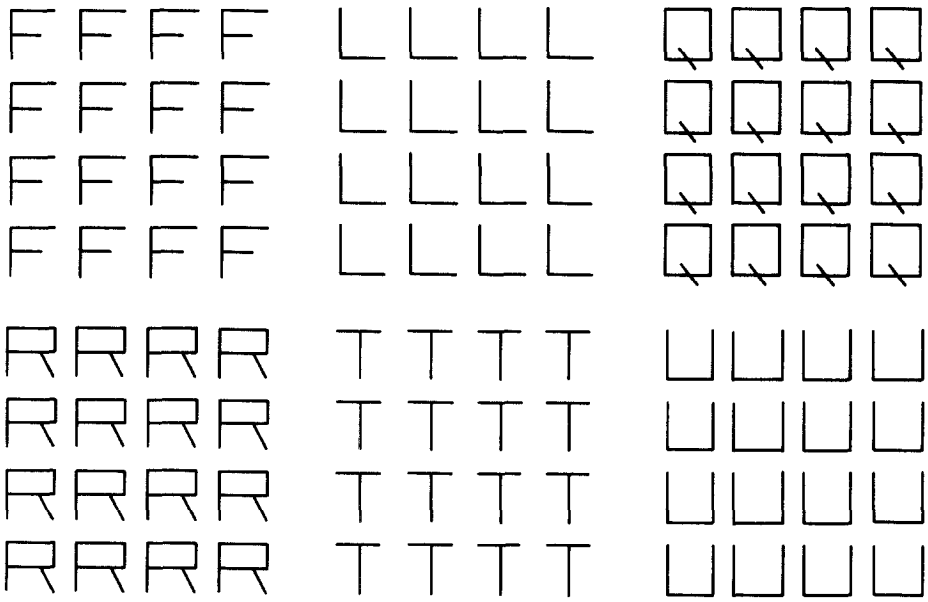

Fig. 1. The six letter matrices used in base condition.

The letter A was used in practice trials. One of the 16 letters in the matrix was critical, i.e. that occupying the 2.2 position. This letter was subjected to six possible conditions of presentation: (1) baseline (static, vertical), (2) movement (horizontally, along the row of letters, to the right), (3) 'inclined' (i.e. rotated by 45 degrees to the right), (4) 'reversed' (upside-down, rotated by 180 degrees), (5) contrasting (coloured green, the other letters being red), (6) not contrasting (coloured pink, the other letters being red).

Procedure

Subjects first performed a practice trial with the letter 'A'. They were shown a 4 × 4 matrix of As and went through the procedure assigned to them for the experimental task. They were asked to consider the matrix as a whole and to rate the vividness of the critical letter by orally indicating a value on a scale between 0 and 99, in which 0 corresponded to 'not vivid at all' and 99 'perfectly vivid'. Subjects experienced all six conditions in the practice trial. In the experimental task, both order of letters and order of conditions were randomized for each subject, the only exception being that the baseline condition was presented first in the imagery trials. This was because pilot experiments had shown that, in this modality, this was necessary to prepare subjects to create the other conditions.

In the imagery modality, subjects were given 5 s to imagine the matrix, 5 s to imagine the critical letter, and then 7 s to give their vividness ratings. In the perceptual modality, subjects had 5 s to look at the matrix and then had to give their ratings. In the perceptual movement condition, a transparent sheet containing a single letter, originally in the critical 2.2 position, was shifted to the right manually by the experimenter, giving the impression that the letter was moving horizontally along the line of the underlying letters.

Results

We first calculated the mean rated vividness for each of the six conditions in each of the two modalities (Fig. 2). With respect to the three kinds of representations (orientation, colour, movement), conditions were manipulated so that each included one representation favourable to perception and one not favourable to it. A $2 \times 2 \times 2 \times 3$ ANOVA for mixed complete design was conducted with gender and modalities as between-subjects factors and kind of image and conditions (favourable-to-perception or not) as within-subject factors. This revealed significant effects due to kind of image ($F(2,52) = 4.79$, $p = .012$; as Fig. 2 shows, static vs. movement has the lowest overall ratings, whereas orientation has the highest), and to the favourable-to-perception condition ($F(1,26) = 83.62$, $p < .001$) with conditions favourable to perception having a higher overall rating, and a significant interaction between kind of image and condition variables ($F(2,52) = 11.74$, $p < .001$). As Fig. 2 shows, the advantage of conditions favourable to perception is less evident in the imagery modality. In particular, as the right-hand part of Fig. 2 shows, the difference between the mean vividness ratings of inclined and reversed conditions is clear in the perceptual modality, but tends to disappear in the imagery modality.

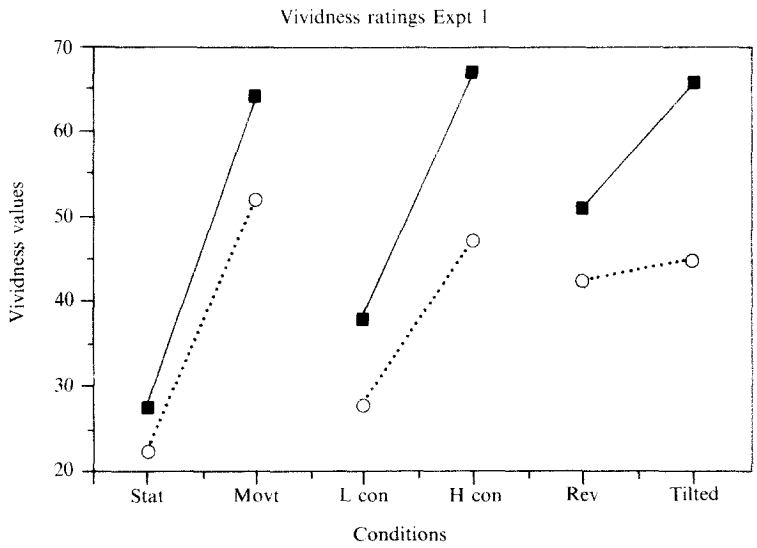

Fig. 2. Mean vividness ratings given either on a perceptual or on an imagery modality for matrices under three different conditions: static vs. movement (left), low vs. high colour contrast (centre), reversed vs. tilted-inclined (right). —■—, perceptual; · · · ○ · · ·, imagery.

We also found significant differences in the main effects of modalities ($p = .045$) and gender ($p = .034$) evidenced by higher ratings in the perceptual modality and in the female group. Further, in an ANOVA which also included the letters as a factor, we found a main effect due to letters ($F(5,140) = 2.45$, $p = .015$), shown by the fact that two letters (T and R) had the highest overall ratings. Nevertheless, neither gender nor letters produced any significant interaction with the other variables.

Discussion

The results of Expt 1 show that, as expected, some differences can be found in phenomenological experience between visual perception and visual imagery. These differences seem to depend on characteristics like colour and degree of rotation which, according to some authors (Beck *et al.*, 1983; Treisman, 1986) are processed at an immediate, pre-attentive level.

This specific perceptual processing seems to affect not only the rapidity of object formation, as has been shown in other research (Treisman & Souther, 1985) but also the vividness of the phenomenological experience. High-contrast coloured and inclined figures appeared particularly vivid in the perceptual modality but less so in the imagery modality. In other words, patterns produced by visual imagery do not compare isomorphically with those produced by visual perception.

Conversely, the differences we found between perceptual and imagery vividness ratings may be reduced or eliminated if perceptual vividness ratings are based on a more active, attentive, constructive perceptual activity – this makes visual perception more comparable to visual imagery. In our second experiment, therefore, we introduced such a perceptual modality by asking subjects to draw the matrices before giving their perceptual ratings. Because of the procedural complication (subjects had to draw a high number of matrices), we made the task simpler by focusing on just some of the experimental conditions.

EXPERIMENT 2

Method

Subjects

Thirty-six students (18 women and 18 men) from the University of Bologna were randomly divided into three groups representing the three modalities (perceptual, imagery, drawing).

Material

Five of the six letters (excluding the letter R) used in Expt 1 were also used in Expt 2, and the letter A was again used in the practice trials. In order to equalize the drawing condition with the imagery and perception conditions, all material was freely hand drawn in black ink on a square sheet of paper made up of squares sized 5 × 5 mm. Each letter was drawn in the area bounded by four squares (2 × 2 squares) corresponding to one squared cm and the distance between two letters was one square. In this case too, each letter was reproduced 16 times in a 4 × 4 matrix, and the experimental letter was again in position 2.2. Unlike the situation in Expt 1, the only general condition rated was rotation, both inclined and reversed positions being added to the basic static condition.

Procedure

The task was identical to that used in Expt 1 for both perceptual and imagery modalities. In the drawing modality, subjects were asked to draw the letter matrix on squared paper. The trial was performed using the three different matrices for each letter A. During the drawing phase, subjects were asked to draw simply and quickly, but clearly.

1. Baseline condition: subjects had to draw the experimental letter at the same orientation as the other letters in the matrix.

2. Inclined (tilted) condition: the experimental letter had to be drawn rotated by 45 degrees.
3. Reversed condition: the experimental letter had to be drawn rotated by 180 degrees.

Once each matrix had been drawn, subjects had to give vividness ratings, as in Expt 1. In the perceptual modality, subjects were asked to rate the vividness of hand-drawn matrices which were substantially comparable to those drawn by subjects in the drawing modality. Imagery modality and other procedural aspects (including randomization) in Expt 2 were identical to those of Expt 1.

Results and discussion

A $2 \times 3 \times 3$ ANOVA for a complete mixed design having gender and modality as between-subjects factors and conditions as within-subject factors revealed the significant main effect of conditions ($F(2,60) = 61.70$, $p < .001$, as the figures in the unrotated basic static condition were rated as less vivid), and a significant interaction of modalities by conditions ($F(4,60) = 4.15$, $p = .005$). Figure 3 shows the mean vividness ratings for the representations in the three conditions for the three modalities.

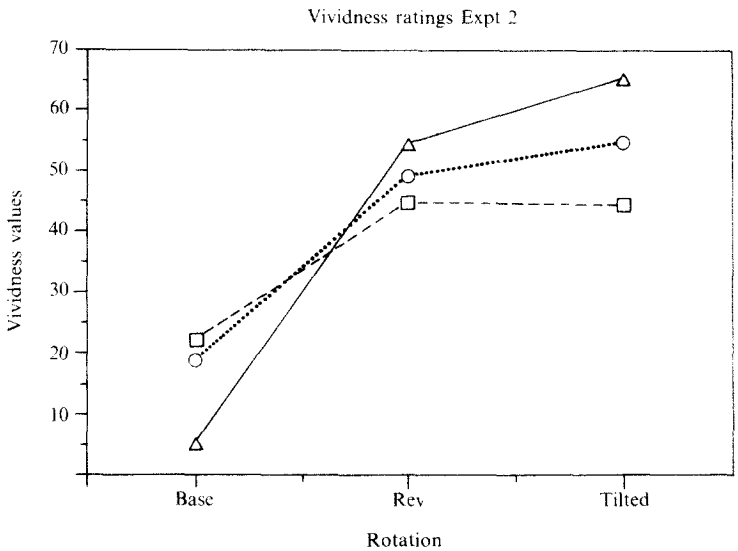

Fig. 3. Mean vividness ratings given either on a perceptual, or on an imagined, or on a drawing base for matrices having an experimental letter differently rotated: base (0 degrees), reversed (180 degrees), tilted (inclined at 45 degrees). —△—, perceptual; · · · ○ · · ·, imagery; – –□– –, drawing.

The interaction can be seen especially clearly as the perceptual modality involves ratings different from the other two. This interaction is made even clearer by planned comparisons which reveal that the basic static condition evokes lower ratings in the perceptual modality than in the drawing ($p = .036$) and imagery ($p = .08$) modalities, and that the inclined condition evokes higher ratings in the perceptual modality than in the drawing modality ($p = .017$), and that no significant difference emerges in the reversed condition. The different reactions in the inclined and reversed conditions for the three modalities are highlighted by the fact that the only case in which a significant difference was found between the two conditions was in the perceptual modality ($p = .031$). In this case we did not observe a main effect due to gender.

However, this variable did influence the pattern of results in some way, as indicated by the significant interaction between gender and modality ($p = .034$): although women gave higher ratings than men in the imagery and drawing modalities, the opposite result occurred in the perceptual modality.

The results of Expt 2 reveal that perceptual vividness ratings are affected by the characteristics of the underlying visual processes and differ according to whether subjects are involved in preceding attentive, constructive activity or not. The difference seems to concern the nature of the cognitive processes involved, rather than unavoidable characteristics of the judgements based on the presence or absence of the pattern.

In fact, even when a pattern was perceptually present and it involved a constructive activity, it acquired characteristics similar to the absent pattern, created through imagery. For the same reasons it should be possible to find a situation in which an absent pattern, accompanied by minimal constructive activity, should be more similar to a perceived than to an imagined pattern. Such a situation might be produced when a pattern, rather than being constructed through an active imagery process, is retrieved from memory after recent prolonged perceptual exposure. This case was studied in Expt 3.

EXPERIMENT 3
Method

Subjects

Forty-eight mainly female students from the Universities of Bologna and Padova were randomly divided into three groups representing the three modalities (perceptual, imagery and memory).

Material

The same matrices and three letters (F, T and U) used in the preceding experiments were also used in Expt 3. In the perceptual and memory modalities they were represented in the experimental position 2.2, either reversed or inclined. For the memory condition, each matrix was associated with a two-syllable concrete noun beginning with the same letter in Italian (fiore-flower, fuoco-fire, tetto-roof, torre-tower, uomo-man, uovo-egg), with a balance between the nouns and the reversed–inclined matrices.

Procedure

Subjects were tested individually. In the memory condition, the six matrices were presented in random order in association with the nouns. In the following presentations, using a paired-associate learning procedure, subjects were asked to give the nouns associated with the matrices. After the first completely correct trial, subjects had to give judgements of the vividness properties of each matrix, based on their recall of the matrix. They were presented with each noun and asked to rate the vividness of the experimental letter in the matrix, using the usual procedure. The order of presentation of matrices was changed and randomly defined for each trial and for the vividness rating.

The subjects of the perceptual and imagery conditions rated the vividness of the same matrices following the procedure of the preceding experiments, the only differences being the smaller number of matrices (introduced to make the memory task easier) and the time available for each matrix. In fact, in order to make the overall times in the three conditions comparable, each subject of the memory group

was paired to one subject of each of the other groups in such a way that the time available for each matrix before giving vividness ratings corresponded to one-sixth of the overall time required in the memory condition. This matching was made possible by the fact that, given the low number of matrices, the paired-associate task required a limited amount of time (around two minutes). Two subjects, one who required more than four minutes and the other who had problems in retrieving the matrices, were discarded.

Results and discussion

Figure 4 shows the mean vividness ratings given for the reversed and inclined letters in the three conditions.

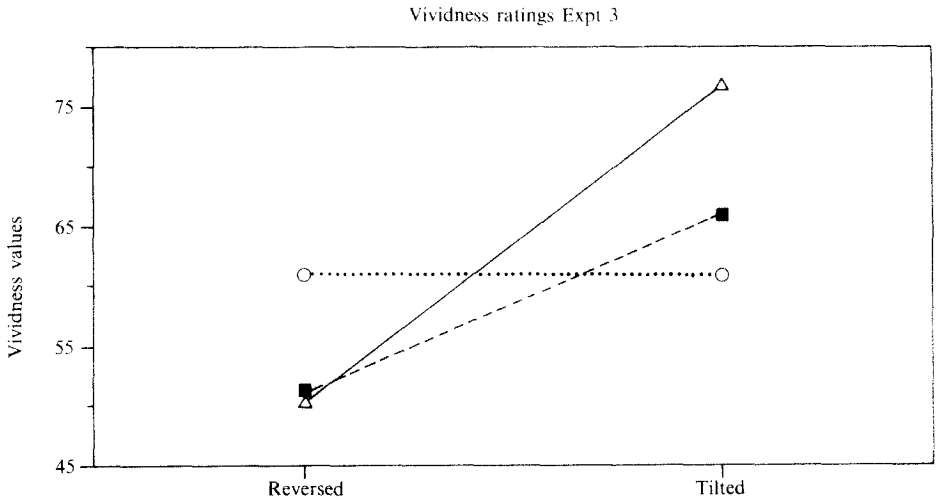

Fig. 4. Mean vividness ratings given either on an imagined, or on a perceptual or on a memory base, for reversed and tilted (inclined) matrices. ····○····, imagery; —△—, perceptual; — ■ —, memory.

A 3 × 2 × 3 ANOVA for a mixed design, having as a between-subjects variable the three modalities (perceptual, imagery and memory) and as within-subject variables the letter conditions (reversed and inclined) and the three letters, revealed main effects for conditions ($F(1,45) = 38.81$, $p < .001$) and the letters ($F(2,90) = 3.26$, $p < .05$). The first effect confirms the general observation that the inclined letter is typically rated as more vivid than the reversed one (mean ratings respectively 67.89 and 54.13). The second effect supports the observations that the different letters have different vividness ratings: in this experiment, the letters 'F' ($M = 64.04$) and 'T' ($M = 62.1$) obtained higher ratings overall than the letter 'U' ($M = 56.88$), whose practically closed shape makes variations caused by rotational transformation less evident, especially in the case of the reversed condition, as suggested by the significant interaction between letters and conditions.

The ANOVA also revealed a significant interaction between modalities and conditions ($F(2,45) = 12.24$, $p < .001$). Figure 4 shows that, in the imagery condition, the ratings are similar for the reversed and inclined matrices, in which the inclination advantage occurs not only in the perceptual modality, but also, although to a lesser extent, in the memory modality. Planned comparisons confirmed that in both these cases, but not in the imagery modality, the difference between the reversed

and inclined conditions was significant (both $p < .001$). The interaction modalities × conditions was further defined by a third-order interaction comprising all three variables ($F(4, 90) = 6.15$, $p < .001$) which seems due mainly to two factors. First, in the imagery modality, the reversed letter 'T' obtained the highest mean rating. Second, in the perceptual modality, whereas the reversed letter 'U' obtained the lowest mean rating, the inclined letter 'U' obtained the highest mean rating. These results are clear if we consider the geometric characteristics of these two letters. 'T' is formed from a vertical and a horizontal upper segment, in the absence of a corresponding horizontal segment at the bottom: therefore, in the reversed condition – in the imagery modality – the 'weight' of the letter is strongly modified giving the impression of a substantial transformation. As regards the 'U' it always had low ratings except when it was inclined and a perceptual presentation produced a clear pop-out effect. The perceptual effects of the inclined and reversed letters can be seen in Fig. 5.

The results concerning the letters confirm the observation of Massironi & Luccio (1989) that the formal properties of the figures can influence not only observers' perceptual responses, but also – in a different way – their responses provoked by imagery. This particular result and the different vividness impressions evoked either by the inclined or by the reversed letter in the perceptual and imagery modalities confirm the observations of Expts 1 and 2 regarding the differences between perception and imagery.

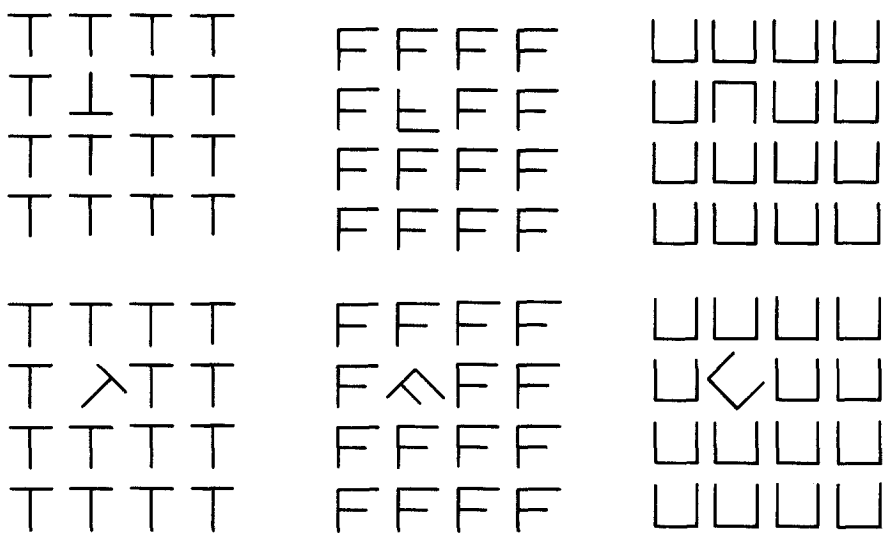

Fig. 5. Matrices used in Expt 3 for the inclined and reversed conditions.

Further, the difference found between the imagery and memory modalities shows that the effects found in the imagery modality are not simply the effect of a memory judgement, but are due to the activity involved in the imagined construction of the matrix. As the subjects in our memory group did not know the nature of the second phase of the experiment, their ratings could not be due to the recall of conscious

judgements given during the perceptual exposure involved in the paired-associate learning phase. Their ratings seem to be based on the overlearned visual memories of the matrices which, after a short interval, are affected by the long session of perceptual activity, although they are to some extent attenuated.

GENERAL DISCUSSION

The debate concerning the existence and properties of visual imagery has mainly concentrated on its functional properties. While attempting to demonstrate the existence of analogic processes resulting from imagery and representations distinguishable from more abstract propositional processes, imagery theorists have been at pains to show the relationship between visual perception and visual imagery (Intons-Peterson & McDaniel, 1990). This approach appears less compelling if visual imagery is studied with reference to the structural rather than functional properties of phenomenological experience in the imagination. The extensive and crucial existence of this kind of phenomenological subjective experience cannot be denied, whereas the problem of studying its qualities remains open. The present research aimed at studying the qualities of the experience evoked by the requirement to create images whose corresponding perceptual configurations were believed to be partially different.

It was hypothesized that visual perception may involve different processes, some of which – pre-attentive and not under voluntary control – are very far from the constructive, voluntary, attentive processes typically involved in the creation of visual images (Neisser, 1967). Such pre-attentive perceptual processes appear particularly to involve some stimulus characteristics such as colour, movement and rotation. By manipulating these characteristics, we found that some of their values (e.g. movements vs. static condition, high vs. low colour contrast, inclined vs. reversed targets) were especially capable of priming visual perceptual processes and causing subjective experiences of great vividness in the perceptual modality. These effects confirm Treisman & Souther's (1985) description of a 'pop-out effect' in which the target stimulus emerges from other, similar, distracting stimuli. This effect was less evident in the imagery modality. Imagery ratings showed similarities and differences with respect to perceptual ratings in all three experiments.

In Expt 1 we found that for imagery too, although the conditions defined as 'favourable to perception' gave higher ratings than 'non-favourable' conditions, the effect was less evident. The fact that the basic static condition gave very low ratings in both modalities suggests that subjects rated the emergence of the experimental letter in the matrix and, when the experimental letter was identical to all the others, they gave low ratings because this emergence was strongly reduced. The differences between the perceptual and the imagery modalities were replicated in Expts 2 and 3, showing the consistency of the effect.

It could be argued that, in the imagery modality, subjects' ratings were based on tacit knowledge concerning perceptual functioning or the emergence of the properties of different figures. This argument brings us back to the ontological question which we did not wish to consider; however, we would like to observe that the only partial similarities found between perception and imagery allow us to reject the theory that people use tacit knowledge concerning visual perception functioning.

Although the concept that inclined figures are more evident than reversed ones is probably unknown to ordinary people, knowledge concerning colour contrasts is highly familiar. Nevertheless, in our imagery modality subjects underestimated the differences in colour contrast: in our opinion, this is because, in imagery, even the difference between pink and red may be large. At the same time, evidence of perceived objects is generally higher than evidence of imagined objects and this may explain why we found a general effect of modality, which reduced the ratings for imagined matrices with respect to the corresponding perceived ones. Further, as regards the reversed–inclined condition of all three experiments, we did a further check by requiring a group of university students to evaluate, without the use of imagery, but only on the basis of a quick knowledge-based judgement, whether in a matrix of letters in the same position a letter would appear more distinguishable if it were reversed or inclined and the large majority (72 per cent) of our subjects considered a reversed letter more distinguishable. This judgement was significantly different from that given by another group of subjects asked to use imagery in order to decide which letter should appear more distinguishable: in this case, the majority of subjects (63 per cent) indicated the inclined letter.

In Expts 2 and 3, in contrast to Expt 1, the absolute values of ratings in the imagery modality were comparable to those found in the perceptual and drawing modalities. This result leads us to consider the few procedural differences between the experiments, starting from the fact that in Expt 2 perceptual ratings were based on free-hand drawings rather than on good, well-defined, high-quality outlined matrices as in Expt 1. This variation may also explain why women, who tended to give higher ratings in all modalities in Expt 1, did not behave in the same way in the perceptual modality of Expt 2 (in Expt 3 the gender variable was not considered because the subjects were mainly females). Further, in Expt 3, the low overall number of experimental matrices may have contributed to giving the overall vividness impression of the figures. At the same time, this variation did not compromise the comparability of the three experiments, since in all cases the perceptual groups rated the three common conditions similarly, giving the highest ratings for inclined letters, medium ratings for reversed ones, and the lowest ratings for basic static ones.

If we consider that in the perceptual and drawing modalities of Expt 2 subjects were asked to rate the vividness of the same matrices, it may be surprising to find differences in the two modalities. However, on the basis of our hypothesis that different visual processes may be distinguished, the results become clearer, since ratings for the perceptual modality were based on immediate, automatic, visual processes in which some stimulus characteristics are particularly active and may produce pop-out effects, whereas ratings in the drawing modality were based on successive, attentive and constructive processes. Similarly, if we consider that a visual trace is in some respects comparable to a mental image, the result of Expt 3, showing the differences between the imagery and memory modalities, is also somewhat surprising. Nevertheless, the results confirm our hypothesis that differences between perception and imagery can be found when different processes are involved. In particular, if a constructive activity, as in many typical imagery situations, is also involved in the perceptual modality, the perceptual impression is similar to that evoked by the image impression. If, on the contrary, the visual memory representation is the direct by-product of a perceptual exposure, the memory

(perceptual imagery) impression is similar to the impression evoked by the perceived matrix.

Coming back to the classic question of the relationship between visual perception and visual imagery, we believe that the scientific debate has now reached the point at which an increasing amount of evidence shows that not only similarities but also differences are present. Farah (1989) recently assumed a similar point of view when she argued that imagery is an attentive activity, the response being faster when focused parts of the images are considered. In the present research, the characteristics which are particularly active during pre-attentive immediate visual processing appear more critical in influencing the qualities of perceived objects than those of imagined objects. The great similarities found between the imagery and drawing modalities suggest that similar processes may be involved in both, although their identification requires further research. In particular, we do not know exactly which processes were involved in the drawing modality and which processes were critical in determining the difference between the perceptual and drawing modalities. In the drawing modality, the effects of immediate pre-attentive visual processes were reduced both by the delay involved at the moment of rating and by active attentive processes during drawing activity. Although it could be argued that drawing requires a particular kind of perceptual activity which is the same as that involved in visual imagery, it seems difficult to deny that even mental representations, including imagery, can influence drawing activity. Otherwise, how can people plan their drawing processes in order to produce the required patterns?

Lastly, we would like to add some brief comments on the vividness dimension we used for obtaining subjective ratings. Our assumption was that subjects could give vividness ratings of perceived and imagined objects in the same way as they could give other subjective ratings, as many psychophysical studies have shown. Equally, we believe that ratings may be affected by boundary conditions (in our experiments, for example, a specific stress may have been given to the relationship between the experimental letter and the other letters) or by a variety of image properties which can be separately studied. A recent paper (Cornoldi *et al.*, 1991) stressed how different characteristics (e.g. shape, detail, etc.) and instructions can influence vividness ratings.

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