The Bells Test: A Quantitative and Qualitative Test For Visual Neglect

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The Bells Test, a cancellation task, permits a quantitative and qualitative evaluation of visual neglect. The construction of the test allows for rapid visualization of the spatial distribution of the omitted targets and their quantification. The examiner can also obtain a qualitative picture through an approximation of the visual scanning pattern used by the subject; this provides valuable information on "how" the task is performed. In summary, the Bells Test is a more dynamic, and thus, more sensitive clinical examination for visual neglect.

The aim of this paper is to present the Bells Test, a test for visual neglect which allows for an approximation of the subject's visual search strategy, and permits the detection of mild and moderate visual neglect. Visual neglect is defined here as a lack of response or attendance to visual stimuli presented to the left or to the right of the median line of the body and/or head.

Numerous visuo-motor tasks using paper and pencil have been proposed to unmask visual neglect. Some of the most popular are the Albert's Test (Albert, 1973) in which the subject crosses-out lines, or the various letter cancellation tasks developed by Diller and Weinberg (1977). The test we present, called the Bells Test, follows similar rules: the subject must circle all the targets (bells) he encounters. However, in the Bells Test the performance of the subject can be evaluated quantitatively (how many bells are omitted and where) and qualitatively (how was the visual scanning carried out).

DESCRIPTION OF THE BELLS TEST

The Bells Test was devised following the same general principle as the Albert's Test: seven columns, each containing a fixed number of targets. The subject believes the distribution is at random. This similarity permits the comparison of the subject's performances on the two tests.

A 21.5 x 28 cm sheet containing different outlines of objects (house, horse, bell...) is presented to the subject (Figure 1). A total of 35 targets (bells) are distributed equally in 7 columns (Figure 2). In each column, there is the same number of targets ($N=5$) and of distractors ($N=40$). All drawings are black like chinese shadows.

Of the 7 columns, 3 are on the left side of the sheet, one is in the middle and 3 on the right. Therefore, if the subject omits to circle bells in the last column on the left, we can estimate his visual neglect as being mild. However, omissions in more centered columns can suggest a greater neglect of the left side of the space. There is a balanced number of targets in each of the quadrants.

ADMINISTRATION OF THE BELLS TEST

The subject is comfortably seated with both forearms on the table. The examiner is seated facing the subject. First a "demonstration" sheet is presented to the subject: this sheet contains an oversized version of each of the distractors and one circled bell. The subject is asked to name the elements indicated by the examiner in order to ensure proper object recognition. If the subject experiences language difficulties or if the examiner suspects comprehension problems, the subject is invited instead to place over each element a card representing that object.

The examiner then gives the following instructions: "Your task will consist of circling with the pencil *all* the bells that you will find on the sheet that I will place in front of you without losing time. You will start when I say "GO" and stop when you feel you have circled all the bells. I also ask you to avoid moving or bending your trunk if possible." If a comprehension problem is present, the examiner has to demonstrate the task.

The task sheet is then placed in front of the subject with the black dot on the subject's side, centered on his midsagittal plane. The task sheet is thus given after the instructions.

The examiner holds the scoring sheet away from the view of the subject and with the dot towards the subject. This up-side down position facilitates the examiner's task. After the starting signal, the examiner notes by successive numbering on his sheet (e.g. 1, 2, 3...) the order of circling of bells by the subject. If the subject circles another element, the examiner indicates on his scoring sheet by the appropriate number the approximate location. The subsequent bell receives the next number.

If the subject stops before all bells are encircled, the examiner gives one and only one incitement in the following terms: "Are you sure that all bells are now circled? Verify again." After the incitement, the order of numbering is still pursued but the numbers are encircled or underlined. The task is completed when the subject stops his activity.

TABLE 1
Summary of Mean Scores on Bells Test

	Controls	Brain Damaged	
		Right	Left
	(n=20)	(n=19)	(n=20)
Sex (M/F)	8/12	13/6	7/13
Age Mean	71.2	67.7	69.3
SD	5.1	10.2	7.3
Mean Total Score	33.3	28.8*	32.3
SD	1.3	3.9	3.5
Mean Number of Left Omissions	.8	4.6	1.0
SD	1.0	3.5	1.4
Mean number of Right Omissions	.6	1.2	1.4
SD	.7	1.1	2.2

Statistical analysis
Sex: NS, Chi-square Age: NS, F(2,56)=.98 Mean Total Score: p=.001, Mann-Whitney

SCORING AND INTERPRETATION

The total number of circled bells is recorded as well as the realization time. The maximum score is 35. The examiner can then appreciate the spatial distribution of the omitted targets and evaluate the severity of the visual neglect, for example in the left hemispace in the case of a right brain damaged subject. Completion time is not a valuable indicator of success or neglect. Normal subjects have taken from one to five minutes with no omissions; BD subjects have required from one and a half to five minutes with varying number of omissions. The realization time can be useful when repeated measures over time are taken. An intra-individual comparison can then be made by the clinician.

How the subject proceeds during the scanning task can be viewed by connecting the bells of the scoring sheet according to the order of numbering. In our setting, the approximation of the scanning pattern is given by computerized graphics using curves tracing subroutines (Pinard, Ward, & MacPherson, 1983) on a CYBER 853 computer at the University of Montreal. Figure 3A gives an example of a graphic representing the vertical scanning pattern of a 69 year-old normal subject, while 3B shows an horizontal scanning of another normal subject (62 years old). In our experience, the visual scanning strategy usually starts on the left-hand side. Interpretation of the scanning strategy is more subjective as any two brain damaged subjects will show different patterns. However, the scanning strategy of normal subjects falls within two distinct organized and systematic patterns: a vertical and an horizontal one. The subjects presenting an attentional deficit will demonstrate a disorganized and chaotic scanning. The regression of the visual neglect syndrome can thus be accompanied by a reorganization of the scanning strategy of the brain damaged subjects.

TABLE 2
Distribution of Subjects According to the Number of Omitted Bells in Each Field

	Controls	Brain Damaged	
		Right	Left
	(n=20)	(n=19)	(n=20)
<u>Number of Left Omissions</u>			
0	11 (55%)	1 (5.3%)	10 (50%)
1-3	9 (45%)	8 (47.1%)	8 (40%)
4-35	0	10 (52.6%)	2 (10%)
<u>Number of Right Omissions</u>			
0	11 (55%)	5 (26.3%)	10 (50%)
1-3	9 (45%)	13 (68.4%)	7 (35%)
4-35	0	1 (5.3%)	3 (15%)

Statistical analysis
Left omissions: S = .001, Chi-square Right omissions: S=.099, Chi-square Left vs Right omissions in RBD: p=.003, Wilcoxon matched-pairs signed ranks test

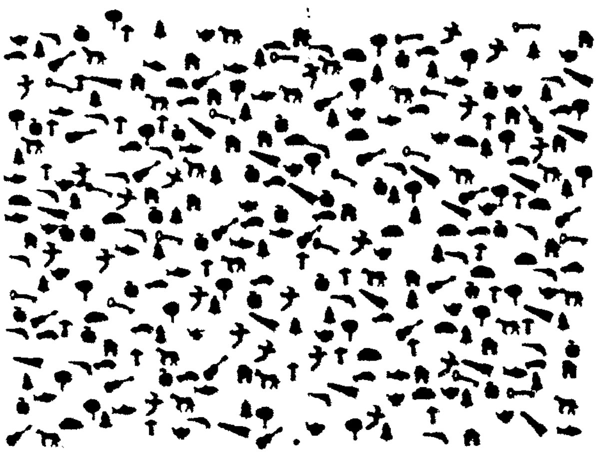

Figure 1
Bells Test task sheet presented to the subject.

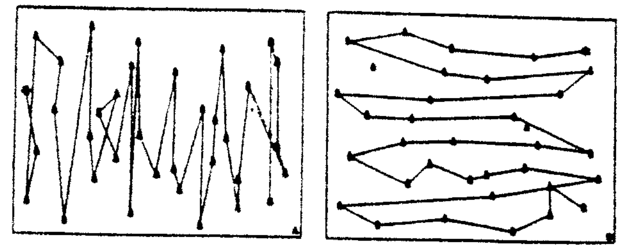

Figure 3
Computerized graphics of scanning stategies of normal aged subjects. In A, a vertical scanning strategy: in B, an horizontal one. The star indicates the starting point.

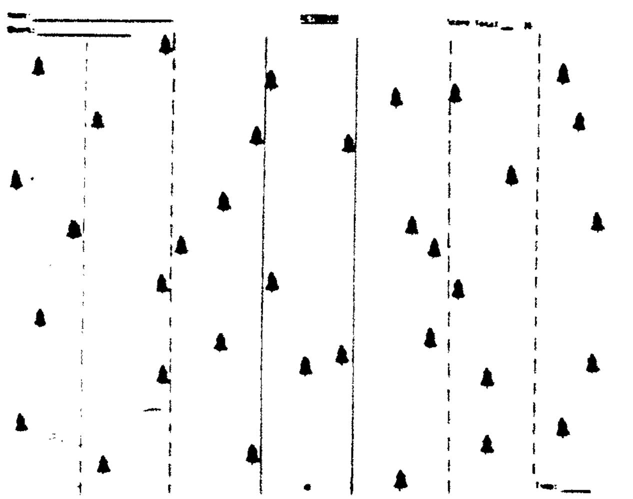

Figure 2
Bells Test Scoring Sheet Used by the examiner.

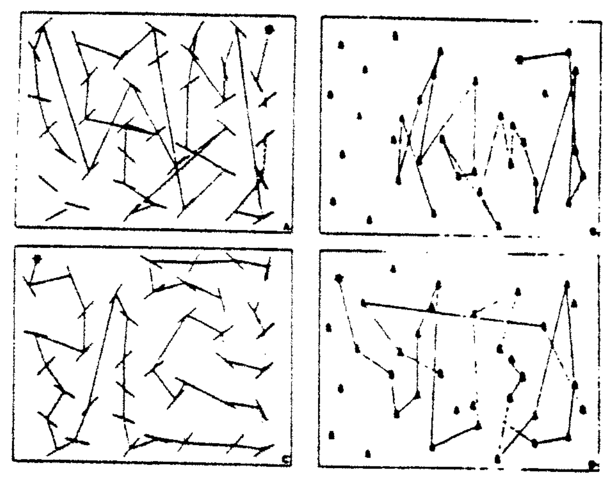

Figure 4
Performance with the Albert's Test (A & C) and the Bells Test (B & D). Graphics 4 A-B are the performances of a right brain damaged subject without homonymous left hemianopsia. Graphics 4 C-D represents the visual scanning strategies of a left hemi-parkinsonian. In both cases, visual neglect is evidenced by the omitted targets in the left side of space of the Bells Test. The star indicates the starting point.

Figure 4A-B represents respectively the performance of a right brain damaged subjects (64 years old) without homonymous left hemi-anopsia, with the Albert's Test and with the Bells Test. the spatial distribution of errors with the Bells Test demonstrated the neglect of the targets on the left side; the approximation of the visual scanning search pattern is very disorganized compared to the normal subject here starting from the right (figure 3A & B). The performances of a 67 year-old left hemi-parkinsonian (i.e. right CNS degenerescence) are presented in Figure 4C-D; again the Bells Test permits delineation of possible inattention of the left side of space. (The examples given in Figures 3-4 were realized using a preliminary version of the Bells Test. The final version presented in this paper is different by the fact that two bells of the lower *right* quadrant were displaced to the upper *right* quadrant in order to balance the number of targets in each quadrant. However, this does not change the performance represented in these figures in the left side of the test sheet). In these examples, as it was the case in all brain damaged individuals tested with both the Albert's and the Bells tests, there is a greater number of omitted targets with the latter.

PRELIMINARY NORMATIVE STUDY

The Bells Test was presented to a population of 59 right-handed subjects: of these, 20 were controls without previous neurological deficits, 19 suffered a right cerebrovascular accident (CVA) and 20 a left CVA. The CVA subjects were none selected and were evaluated following their referral for neuropsychological evaluation. For all the brain damaged subjects, it was the first cerebral insult, and all lesions were unilateral. The control subjects were inpatients at the same hospital who did not suffer from any neurological or visual deficits. They were all volunteers and presented various medical conditions (cardiac or digestive problems, hip fractures, etc).

Testings were done within three months of CVA in all cases and by two independent neuropsychologists. Data analysis is based on the total score of the subjects on the Bells Test and on the number of bells omitted in the three right or left columns of the test.

There is no significant difference between the three groups for sex and age. Table 1 summarizes all subjects performances on the Bells Test, as well as the average of left and right omissions for the corresponding columns of the test. The right brain damaged (RBD) subjects' mean score is significantly different from the mean scores of the left brain damaged (LBD) and control groups. The distributions of omitted stimuli in the left and right field for each group are presented in Table 2; here a Chi-square analysis shows a significant difference in the groups' distribution of left omissions. This difference is to be attributed to a subgroup of RBD subjects (N=10) who have omitted more than 3 bells in the left field. A closer inspection of the omissions of RBD subjects evidence a significant difference between the number of omissions in the left space versus the right (p=.003, Wilcoxon matched-pairs signed ranks test). The results are thus in accordance with the accepted knowledge that the RBD subjects perform worse and neglect more on the left than on the right hemi-space.

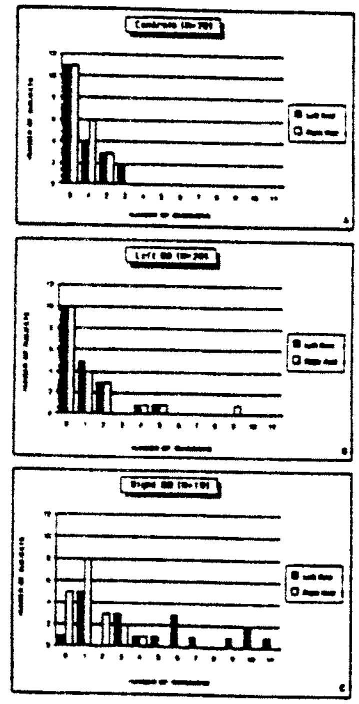

Figure 5
Distribution of omitted stimuli for the control subjects (A), the left brain damaged subjects (B), and the right brain damaged for each half field.

A more detailed account of the distribution of omissions for each group is given in Figure 5. Half the control subjects obtained a perfect score; the maximum number of omitted bells in the group is 3. Thus, it can be safely suggested that more than 3 omissions in either the left or the right columns would be indicative of a deficit in directed attention to the corresponding space. It is to be noted that 10 RBD subjects omitted, in the three left columns, four bells or more, and one RBD subject showed 4 right omissions. A subgroup of those RBD subjects (8/19 or 42%) produced six omissions or more in the left space; such lowered performance strongly suggests the presence of left visual neglect in these individuals. The results do not permit, at the present time, any particular conclusion with respect to the LBD group; the distributions of omitted bells are quite similar in each field. However, it can be noted that a small number of them (3/20) showed 4 or more right omissions.

In summary and given the present results, it can be said that if a subject has a total score of less than 32 (more than 3 omissions), then he should be suspected of having an attentional deficit. However, if a subject, usually one with a right brain damage, omits six bells or more in the contralateral half of the test, he should be suspected of presenting visual neglect, which will most probably correspond to a left visual neglect in some cases. (Even though not seen in our population, it could be that a LBD subject presents himself with a right visual neglect.)

DISCUSSION

From our preliminary studies with control subjects, ischemic brain damaged and parkinsonians patients (Gauthier, Gauthier, & Joanette, 1985), it is our opinion that the presence of distractors renders this test more sensitive for the detection of moderate and mild neglect. In other studies, the number of target-stimuli has been increased. For instance, Villardita, Smirni and Zappala (1983) and deS. Hamsher and Hua (1984) utilized a line crossing test similar to the Albert's Test format but have increased the number of lines from 40 to 90. However, it does not seem to us that merely by increasing the number of target-stimuli can one come out with a more sensitive detection test. Actually, the task may be "easier" since there are a lot of targets that can be found accidentally. In fact, in order to obtain a finer detection of neglect, it is preferable not to augment the number of targets, but to embed these targets into "background noise" through the use of distractors. We believe the recognition of a specific target within a complex visual scene is more compatible with the usual environmental conditions of our extrapersonal space. A test like the Albert's Test can show striking neglect in severe cases and is very useful in the acute stage of the cerebrovascular accident. The Bells Test, on the other hand, appears to be more suitable in the later weeks or during the rehabilitation period when visual neglect might have started to regress.

Weintraub and Mesulam (1985) report the use of a Cancellation Test (4 task sheets) constructed with random and structured arrays of verbal and nonverbal stimuli. Here also, the 15 targets per quadrant are scattered amongst distractor stimuli. They have found their tasks more sensitive to "subtle or resolving neglect" than cancellation of lines. They report more targets neglected when all targets and stimuli are distributed randomly. These observations are in accordance with our experience of the Bells Test: more sensitivity with background distractors and with random spatial distribution.

Controversies have also arisen concerning the effect of the stimuli characteristics on the arousal level of the two cerebral hemispheres during a visual cancellation task where attention is mobilized (Heilman & Watson, 1978; Kinsbourne, 1977). the choice of objects instead of lines could facilitate the subject's verbalization during the task and thus activate the left hemisphere and mask the deficits attributed to the right lesioned hemisphere. However this possibility could be discarded on the basis of Caplan's results (Caplan, 1985) where subjects presenting neglect showed comparable results on nonverbal and verbal visual cancellations tasks.

The Bells Test can be considered as a complement to other cancellation tasks using lines and letters. The construction of the Bells Test allows a rapid visualisation of the location of omissions as well as of the scanning pattern used by the subjects. The normalization of the scanning pattern can be viewed as an indicator of the regression of the syndrome. The clinician will find the scanning strategy provides a valuable dynamic picture of "how" the test is performed. The Bells Test is sensitive for detection of mild and moderate neglect and permits a better exploration of the clinical manifestations of attentional deficits in space.

REFERENCES

Albert, M. L. (1973). A simple test of visual neglect. *Neurology, 23*, 658-664.

Caplan, B. (1985). Stimulus effects in unilateral neglect. *Cortex, 21*, 69-80.

deS. Hamsher, K., & Hua, M.-S. (1984). Visual Neglect, Visual Inattention and Neurobehavioral Status. *The INS Bulletin, 17*, Nov.

Diller, L., & Weinberg, J. (1977). Hemi-Inattention in Rehabilitation: The Evolution of a Rational

Remediation Program. In E. A. Weinstein & R. P. Friedland (Eds.). *Advances in neurology*, Vol. 18) (p. 63-82). New York: Raven Press.

Gauthier, L., Gauthier, S., Joanette, Y.(1985). Visual Neglect in Left-, Right-, and Bilateral Parkinsonians. *Journal of Clinical and Experimental Neuropsychology, 7*, 145. (Abstract).

Heilman, K. M., & Watson, R. T. (1978). Changes in the symptoms of neglect induced by changes in the task strategy. *Archives of Neurology, 35*, 47-49.

Kinsbourne, M. (1977). Hemi-Neglect and Hemisphere Rivalry. In E. A. Weinstein, & R. P. Friedland (Eds.). *Advances in neurology* (Vol. 18) (p. 41-49). New York: Raven Press.

Pinard, F., Ward, P., MacPherson, G. (1963). *Ensemble de sous-programmes de tracage de courbes: RTUM*. Montreal: Universite de Montreal. *B41-02e*.

Villardita, C. Smirni, P., Zappala, G. (1983). Visual neglect in Parkinson's Disease. *Archives of Neurology, 40*, 737-739.

Weintraub, S., & Mesulam, M.-M. (1985). Mental State Assessment of Young and Elderly Adults in Behavioral Neurology. In M.-M Mesulam (Ed.). *Principles of behavioral neurology* (Vol 26, *Contemporary neurology series*) (p. 71-123). Philadelphia: F. A. Davis Company.

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PROJET NEGLIGENCE

DIRECTIVES :

EPREUVE : REPERAGE DE CLOCHES

1. Le sujet doit être assis de façon adéquate avec les deux avant-bras sur la table. L'examinateur est assis face au sujet.

2. A l'aide de la feuille intitulée "démo", l'examinateur donne les consignes suivantes: "Votre tâche consiste à entourer à l'aide du crayon, toutes les cloches qui se trouvent sur la feuille que vous aurez devant vous, et ceci sans perdre de temps. Je vous demande aussi d'éviter de bouger ou de pencher votre corps. A l'aide du chronomètre, je calculerai le temps que vous prendrez. Vous commencerez lorsque je vous dirai "Allez-y" et vous cesserez lorsque vous aurez entouré toutes les cloches.

3. Si l'examinateur, lors des directives au sujet, doute de la compréhension du sujet, il peut utiliser les petits cartons représentant les divers objets et demander au sujet de les appareiller aux objets de la feuille "démo".

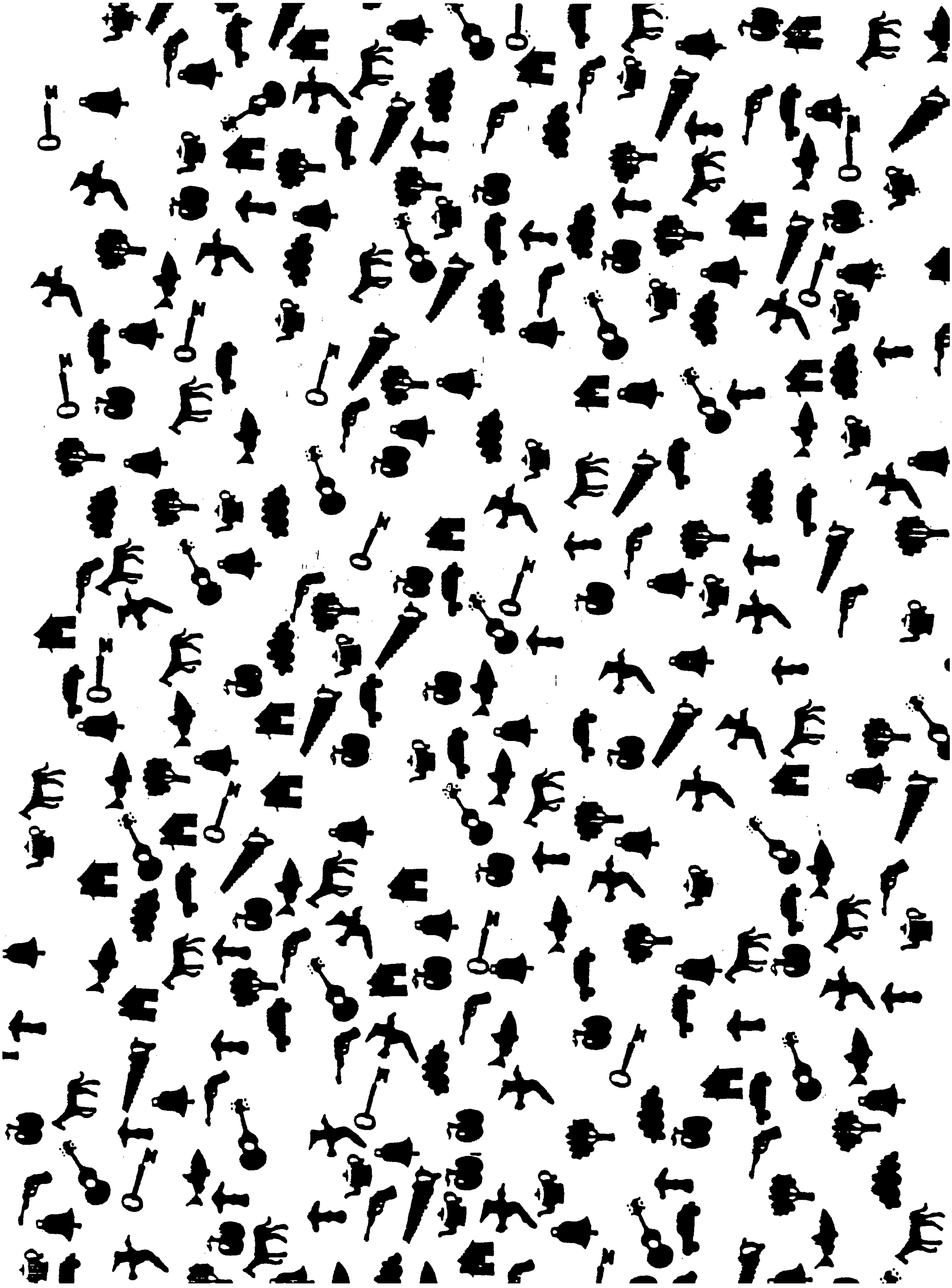
4. La feuille d'examen sera placée en face du sujet et sera fixée sur la table à l'aide de ruban adhésif. Un point noir indique le centre de la feuille; celui-ci se doit d'être en regard du plan mid-saggital du sujet. Un crayon, rouge de préférence, sera placé sur la table du côté de la main choisie par le sujet. La feuille est donnée après les consignes seulement.

5. Pendant la tâche, l'examinateur note par des chiffres successifs (e.g. 1, 2, 3 ...) l'ordre de repérage des cloches du sujet. Si le sujet entoure un autre objet, l'examinateur indique sur son actogramme par un chiffre correspondant à son ordre l'endroit approximatif de l'objet. La cloche qui sera entourée par la suite obtient le chiffre suivant. Il est préférable que l'examinateur place l'actogramme le point vers le haut.

6. Si le sujet arrête avant que toutes les cloches soient entourées, l'examinateur donne une, et une seule, incitation au sujet dans les termes suivants: "Etes-vous bien certain d'avoir entouré toutes les cloches? Vérifiez bien.". Après l'incitation, l'ordre de repérage continue d'être noté (e.g. ⑰ , ⑱ ...) mais l'examinateur entoure d'un cercle les chiffres correspondants aux cloches entourées après l'incitation.

7. L'épreuve se termine lorsque le sujet arrête son activité.

8. Le temps de réalisation de l'épreuve est chronométré à partir de la commande "Allez-y" jusqu'à l'arrêt de l'activité après l'incitation. Le temps de réalisation est inscrit sur l'actogramme.



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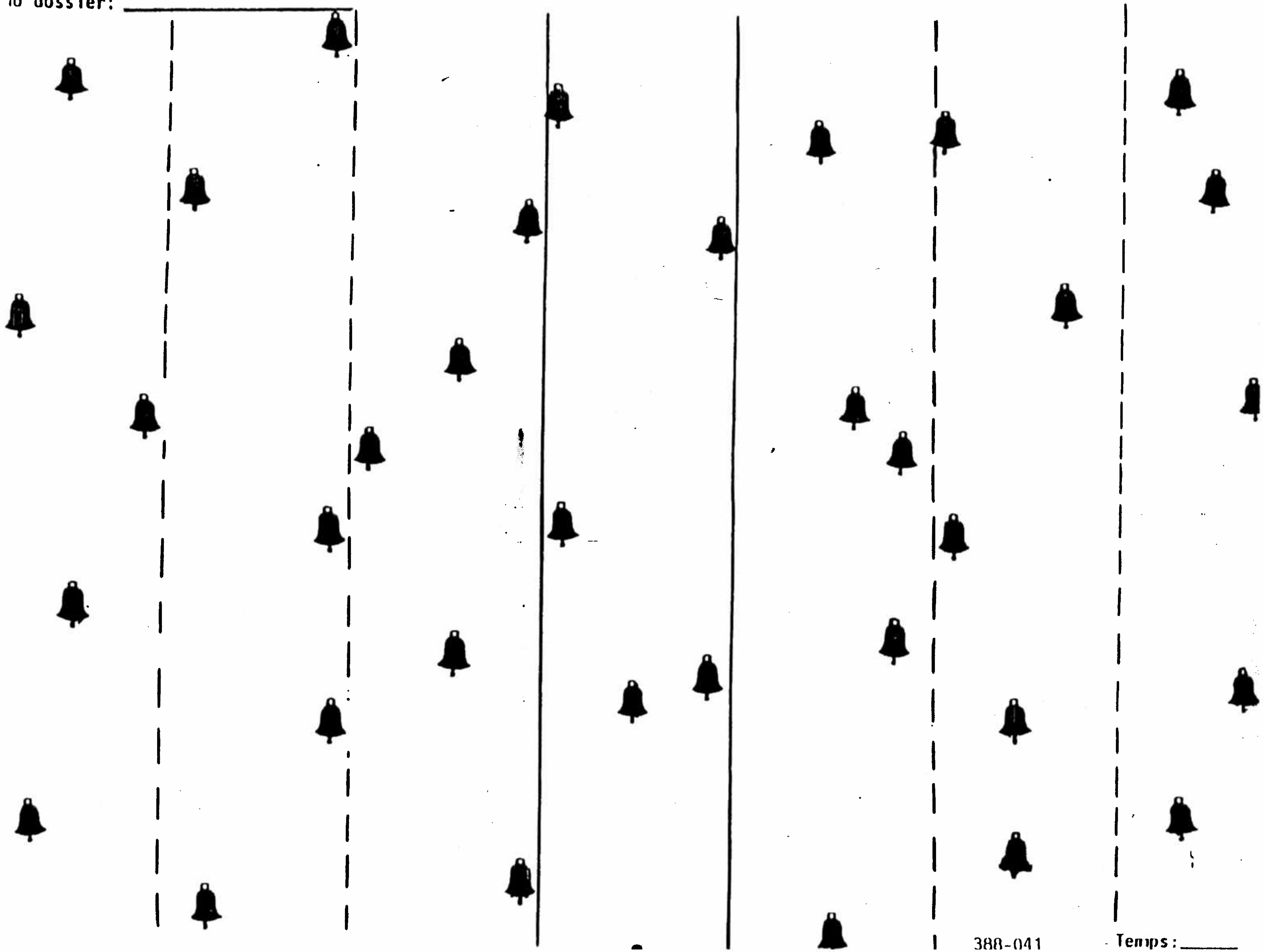
lo dossier: ________________

REPERAGE VISUEL [illegible] L'OBJET CLOCHE

Acto imme

Score:Total___ /35



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Temps:_____