

ACTIONALITY AND MENTAL IMAGERY IN CHILDREN'S
COMPREHENSION OF DECLARATIVES

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ABSTRACT

Previous work has demonstrated that children understand sentences with actional verbs better than nonactional verbs. This actionality effect has been reported to be restricted to passives and independent of experimental context. The present experiment was conducted with 48 French-speaking children aged 5;0 to 7;11. The actionality effect was studied by systematically varying the voice of the test sentences and the voice of the interpretive requests. Pictures corresponding or not to the predicate-argument structure of the sentences were presented to the subjects, who were independently classified as visualizers or nonvisualizers, in order to investigate the relation between sentence actionality and mental imagery. The interaction between actionality, voice of sentence, and interpretive request revealed that the actionality effect depends on the type of task used in order to assess comprehension, and that it can be reversed in some conditions. Our results also suggest that the actionality effect is linked to mental imagery. Visualizers demonstrated better comprehension of actional sentences than nonvisualizers, whereas the reverse was true for nonactional sentences. Mental image may serve as a support for the computations involved in sentence comprehension.

INTRODUCTION

Recent studies have demonstrated that passive sentences constructed around actional verbs are better understood by children than nonactionals, - the so-called actionality effect - (Maratsos, Kuczaj, Fox, & Chalkley, 1979; Maratsos, Fox, Becker, & Chalkley, 1985; Sudhalter & Braine, 1985; Gordon & Chafetz, 1990; Rondal, Thibaut, & Cession, 1990). Maratsos et al. (1979; see also Maratsos et al., 1985) showed that children four-and-five-year-olds understand passives constructed around verbs referring to actions such as kick, and spill significantly better than sentences constructed around nonactional verbs such as know, hear, or like. Sudhalter & Braine (1985) confirmed Maratsos et al.'s results with children aged 3;0 to 4;0. They compared actional verbs to nonactional verbs, the latter belonging to three semantic categories, i.e. experiential (e.g. see), cognitive (e.g. think), and affective (e.g. like). Actional verbs were significantly better understood (between 54% and 58% of correct responses) than the three categories of nonactional verbs (between 26% to 29% of correct responses; the three verb categories did not significantly differ one from the others;). Sudhalter & Braine (1985) interpreted their results as demonstrating that acquisition of passivization rules does not proceed in an all-or-none manner. They suggested that the rules are mastered separately and that acquisition is a gradual process of 'rule strengthening'. They argued that the actionality effect mainly stems from the children's tendency to interpret the preposition by as a cue to actor rather than to experiencer. Maratsos & Abramovich (1975), and Rondal, Thibaut, Cession, Brédart, & Kaens (1988) had already shown that the presence of by is a sufficient condition for subjects to interpret a sequence such as NounPhrase-be+past participle-by-Noun Phrase as a full passive. When preposition by is absent, in a sentence such as The girl is hit the boy, the sentence is understood as an active. Sudhalter & Braine (1985) claim that, in the case of an experiential verb, by cannot be interpreted as introducing the agent. Children using a subject-verb-object strategy may therefore be led to interpret nonactional passives as actives. However, Gordon & Chafetz (1990) demonstrated an actionality effect in truncated (agentless) passive sentences which is in opposition to Sudhalter & Braine's proposal.

Maratsos et al. (1985) have proposed an analysis of the actionality effect in terms of semantic transitivity. Semantic transitivity (see Hopper & Thompson, 1980) entails the transfer of a property from a grammatical subject (GS) to a grammatical object (GO) through the mediation of a verb. According to Hopper & Thompson (1980), high transitivity exists in sentences implying two or more participants, verb actionality, a clear point of departure and ending of the referred action, and punctuality. In such sentences, the agent typically is high in potency, and the patient is well individuated, and affected. For example, a sentence such as John chops the wood may be considered high in transitivity, whereas a sentence such as John sees the girl is lower in transitivity (see Rondal & Thibaut, 1992, for an extensive discussion of the transitivity features identified by Hopper & Thompson). Maratsos et al. (1985) indicate that the sentences which were best understood in their experiments had the characteristics of high transitivity. They state 'It seems to be this semantic-structural core of relatively high transitivity from which children eventually spread their analysis of the productive range of passive (p.189)'.

Gordon & Chafetz (1990) refer to Maratsos et al. and Sudhalter & Braine's theories as class-based accounts of the actionality effect to which they oppose a so-called verb-based account. According to the verb-based account 'children are limited in their knowledge of passives by the input. The verbs that they hear in the passive voice are more often actional than non-actional and acquisition is based primarily on item-by-item learning' (p. 229). Children acquire the passive voice first with verbs they have already heard in the passive voice. Gordon & Chafetz (1990) report two sets of data in support of their hypothesis. The first one is a corpus analysis (data coming from Brown's study of the Harvard children, 1973) revealing that the adult input to the children contains a number of truncated passives but only four full passives. Gordon & Chafetz conclude from their analysis that these data are compatible with a verb-based as well as with a class-based account. The second study analyzes the consistency in children's answers on a comprehension task with active, truncated passive, and full passive sentences, in two experimental sessions separated by a week. According to the authors, consistency in the errors and the correct responses in the test and the retest format is a valid cue to the existence of a verb-based learning mechanism. They

claim that a class-based account predicts a random distribution of errors from test to retest. The index they used indicates that response consistency is higher than a random distribution (in their case, this distribution is equal to 50 %). They conclude from this result that their verb-based hypothesis is corroborated. We believe that the observed consistency is also compatible with a class-based account such as the one proposed by Maratsos et al. (1985). The characteristics of actional verbs that render actional sentences easier to understand than nonactional sentences, of course, are the same for the sentences used in a test and retest format (such as the one used by Gordon & Chafetz). This similarity of properties of the sentences guarantees a consistency of results from test to retest.

Rondal et al. (1990) suggested an explanation of the actionality effect within the context of the transitivity notion as proposed by Maratsos et al. (1985). However, while Maratsos et al. linked the actionality effect to a prototypical semantic role, Rondal et al. suggested that the semantic characteristics of the actional verbs (and probably other characteristics defining semantic transitivity as well) render these verbs and the sentences containing them simpler to understand. They hypothesize that actional verbs and the corresponding actional sentences allow subjects to build a mental image, during sentence presentation or immediately following it. This mental representation might sustain the storage process of the sentence in working memory and/or the processing of the sentence in order to answer possible further questions about it (for example, in experimental comprehension tasks). According to this perspective, the actionality effect should be general : actives as well as passives built around actional verbs should be better understood than sentences constructed around nonactional verbs. However, the experiments reported by Gordon & Chafetz (1990), Maratsos et al. (1979, 1985), Sudhalter & Braine (1985), have yielded results revealing an actionality effect limited to passives. In contrast, Rondal et al. demonstrated an actionality effect with active sentences as well. The subjects were aged 5;0 to 5;11. The task used in Rondal et al.'s experiment was more complex than the ones used in the preceding studies. Children received test-sentences that were either : (1) plausible and plausibly reversible -PPR- (e.g. boy (hit) girl); (2) implausible but plausibly reversible -IPR- (e.g. couch (hit) boy); (3) plausible but not plausibly reversible -PNPR- (e.g. boy (hit) couch); (4)

implausible and not plausibly reversible -INPR- (e.g. table (hit) couch). The questions asked in order to evaluate comprehension (i.e. interpretive requests) were formulated in the same voice as the test-sentences or in the other voice.

We believe that the failure to find a significant difference between actional and nonactional active sentences in Maratsos et al.'s (1985) and in Sudhalter & Braine's (1985) experiments may be attributed to a ceiling effect. Maratsos et al. (1985, Expt. 2) presented pictures consistent with the sentence meaning of their sentences. A ceiling effect is likely as soon as 4 years (97% success for the actional sentences and 92% for the nonactional active sentences). At 5;0, the corresponding scores were 99 and 96%, respectively¹. Sudhalter & Braine (1985, Expt. 2) had children aged 4;0 to 5;0 obtaining scores higher than 90% on the active sentences. The difference in the results between Rondal et al.'s study (1990) and the other studies could have to do with the pragmatic nature of the sentences used. Rondal et al. presented implausible sentences in equal proportion to plausible ones whereas the other authors only used plausible sentences. Ceteris paribus, the demonstration of any actionality effect is more likely whenever baseline performance with the sentences is relatively low. Rondal et al.'s data, indeed, report an average performance of 68% in the active sentence-active interpretive request condition where they observed an actionality effect, markedly lower than the 90 to 95% observed by the other authors in corresponding conditions. In Rondal et al.'s experiment, the children could not make use of their world knowledge with the implausible sentences in order to compensate for possible limitations in linguistic treatment (see below). In any case, the absence of interaction observed between the variables Actionality, Voice in the test-sentences, and Voice in the interpretive requests in Rondal et al.'s data shows that the actionality effect is not restricted to passive sentences².

In the experiment reported in this paper, we, first, aimed to replicate the results obtained by Rondal et al. (1990) as to the actionality effect, in confronting actional and nonactional sentences in four conditions obtained in crossing the voice of the test-sentences with the voice of the interpretive requests [A-A (active sentence-active interpretive request), A-P (Active sentence-Passive interpretive request), P-P (passive sentence-passive request), P-A (passive sentence, active request)]. Of particular interest, were possible differences in the

subjects' scores between actionals and nonactionals in the case of a test sentence and an interpretive request formulated in the active voice. More generally, we examined how the actionality effect was related to the performance obtained at the four levels of the variable Voice. Would it be linked (a) to the passive voice in the test-sentence and/or in the interpretive request, (b) or could it be a more general characteristic of the comprehension of declarative sentences ? Given Rondal et al.'s data, we expected the latter possibility to occur.

We also tested the hypothesis of a relation between mental imagery and sentence comprehension. The performance of children independently classified as higher or lower on a scale of imagery capacity (so-called visualizers and nonvisualizers in what follows) were compared as to their scores on sentence interpretation. If the ability to form a mental image is a significant parameter in the comprehension of actional sentences, one should observe an increasing difference in the subjects' performance on actional and nonactional test-sentences in proportion to an increase in mental imagery capacity. In order to classify children as visualizers or non (or less) visualizers, we used two mental imagery tasks : (a) a mental reconstruction task adapted from the Minnesota Paper Form Board or MPFB (see Denis, 1979, for details) in which subjects have to choose among several drawings the one representing the assembly of several forms previously presented in isolation; and (b) an adaptation of the mental rotation task designed by Shepard & Metzler (1971).

In addition, we compared different experimental situations which could be expected to favor or to hamper the subjects' performance. We provided various types of drawings to the children at the same time the test-sentences were presented. There were four conditions : (a) no drawing presented; test-sentences and interpretive requests presented alone (Neutral situation), (b) test-sentences and requests presented together with a drawing correctly depicting the predicate-argument relationship of the sentence (Facilitative situation), (c) test-sentences and requests presented together with a drawing depicting the reverse of the predicate-argument relationship of the sentence (Negative situation; for example, if the test-sentence referred to a girl combing a boy's hair, the drawing depicted a boy combing a girl's hair), (d) test-sentences and requests presented together with a drawing bearing no specific relationship with the predicate-argument relationship of the sentence (Irrelevant situation; for

example, test-sentence referring to a girl biting a boy; drawing depicting a girl combing a boy's hair). Our Neutral and Facilitative situations are similar to the situations used in Maratsos et al. (1985). Maratsos et al. interpreted their results as showing that the actionality effect is basically independent of the experimental situation. On the contrary, if our hypothesis concerning mental imagery is correct, we predict that the actionality effect can depend on the experimental situation. Assuming that mental imagery plays an important role in sentence comprehension, our Negative situation could negatively affect actional sentences more than nonactionals because the mental images constructed by the subjects regarding the sentences might conflict more with the drawings presented in the case of actionals than in the case of nonactionals. With nonactionals, it might be supposed either that mental images are usually not constructed, or are less easily constructed when they are constructed at all, or even that they are less precise, than with actionals. Conflict between sentence and drawing can lead to the suppression of the actionality effect or to a reversal of this effect. Such a reversal or a demonstrated lack of systematic link between passive voice and actionality effect, would suggest that the actionality effect is more linked to methodological particulars and to particulars of the sentence treatment than to specific characteristics of the passive voice. We also compared the differences between actionals and nonactionals in the different conditions of the variable Voice at each level of the variable Situation : this was done in order to assess whether the actionality effect is present or not in the cases involving the passive voice within the different levels of the variable Situation.

To summarize, five variables were completely crossed in the experimental design : two class variables (Age and Imagery ; the latter variable consisting of four levels defined on the basis of the subjects' performance in two tasks of mental imagery), and three variables with repeated measures : Actionality (actional and nonactional test-sentences), Voice (active test-sentences-active interpretive requests; active test-sentences-passive interpretive requests; passive test-sentences-active interpretive requests; and passive test-sentences-passive interpretive requests) and Situation (Neutral, Facilitative, Negative, or Irrelevant).

METHOD

Subjects

Subjects were 48 monolingual French-speaking children (24 boys and 24 girls), equally subdivided into three groups aged 5;0 to 5;11 (first group), 6;0 to 6;11 (second group), and 7;0 to 7;11 (third group). All the children had intellectual development within normal limits and were making normal progress in school.

Stimuli

Sixty-four test-sentences were constructed starting from 16 verbs : 8 actional verbs [peigner (comb), renverser (turn over), frapper (hit), pousser (push), laver (wash), porter (carry), tenir (hold), and mordre (bite)], and 8 nonactionals [oublier (forget), aimer (like), admirer (admire), entendre (hear), voir (see), haïr (hate), attendre (wait), imaginer (imagine)]. For an independent assessment of the actionality of the verbs used in the study, a group of 75 first-year university students with no background in linguistics were requested to evaluate 25 verbs for actionality on a 7-point scale (see Rondal et al., 1990, for more details regarding this procedure). On this basis, the 8 highest and the 8 lowest verbs on the actionality scale were included in the study as the verbs defining the two levels of the variable Actionality. The variable Actionality was crossed with the two variables Voice and Situation. The variable Situation had four levels : Neutral, Facilitative, Negative, and Irrelevant. The four levels of the variable Voice were obtained from the combination of the test-sentence voice with the interpretive request voice resulting in the conditions Active-active, Active-passive, Passive-active, and Passive-passive. Each one of the four levels of the variable Voice was constituted by the sixteen test-sentences built around the sixteen experimental verbs (8 actionals and 8 nonactionals). As the variables Situation and Actionality were crossed with the variable Voice, for a given condition of the variable Voice (e.g. the Active-Active condition), each level of the variable Situation was constituted by two actionals and two nonactionals, (Ac1, Ac2, NAc1, and NAc2 at the Neutral level; Ac3, Ac4, NAc3, and NAc4 at the Facilitative level; Ac5, Ac6, NAc5, and NAc6 at the Negative level and Ac7, Ac8, NAc7, and NAc8 at the Irrelevant one) (see Appendix 1 for the sentences used

in the Active-Active condition). The same procedure was adopted for the other three conditions of the variable Voice (Active-passive, Passive-active, Passive-active) using the same sixteen verbs. In order that a given verb would not always be associated with the same level of the variable Situation at the various levels of the variable Voice, the four verbs composing a given level of the variable Situation (e.g. Neutral) in one condition of the variable Voice (e.g. Active-active) were permuted with those of another level of the variable Situation (e.g. Irrelevant) in the other conditions of the variable Voice (e.g. Passive-passive). Three groups of 64 test-sentences were constructed in such a way as to make sure that each verb would appear in each situation. Further, each group of test-sentences had two random orders, resulting in a total of six experimental lists.

All the test-sentences were semantically reversible. They all employed the definite article in the noun phrases to avoid cueing the subjects on the identity of the topic/comment elements, therefore influencing their choice of the logical subject (LS) or the logical object (LO) (Hupet & Le Bouedec, 1975).

Line drawings were prepared for the Facilitative, the Negative, and the Irrelevant situations. In the Facilitative situation, the scenes correctly depicted the meaning of the test-sentences. For example, the test-sentence The girl hits the boy was represented by a picture in which a girl is hitting a boy³. For the test-sentences containing nonactional verbs, drawings were created in which the state referred to by the verb was clearly represented. For example, for the verb see, a boy (or a girl) was depicted pointing a finger toward a girl (a boy) who was standing behind a tree. For the verb admire, one character was represented in the act of applauding another one. In the Negative situation, drawings depicted the actions in such a way to indicate the reverse of the thematic roles in the test-sentences. For the test-sentence The boy hits the girl, the drawing depicted a girl hitting a boy. In the Irrelevant situation, the action expressed in the test-sentence had no counterpart, but the action depicted in the drawing corresponded to a verb with an actionality level equivalent to the one of the verb of the test-sentence. For example, for the test-sentence The girl bites the boy, the drawing figured a girl combing a boy's hairs.

The two mental imagery tasks were adapted from previous published studies. The

first one, a so-called mental reconstruction task, was adapted from the Minnesota Paper Form Board (MPFB). In this task, the subject is presented with four cards, each one displaying a set of geometrical forms. The first card (reference card) is composed of several forms randomly juxtaposed; for instance, a rectangle, a triangle, and a circle. The other three cards depict conjoined forms representing a possible arrangement of the reference forms (target card) and two distractors (consisting of different forms). There are twelve similar items. Correct response consisted in matching the target card with the reference card.

The second task was adapted from Shepard & Metzler's mental rotation task (1971). The starting point is a standard representation (for example, the drawing of a pencil) presented in three successive orientations. There are ten items presented in order of increasing difficulty. Subjects had to select among three possible solutions the one depicting the stimulus in the correctly rotated form.

Procedure

The subjects were randomly assigned to one of the six lists of test sentences. Prior to the beginning of the experimental task, four familiarization items were given. Subjects were told 'If I said to you a sentence like Le garçon frappe la fille (The boy hits the girl) and asked you Qui frappe ? (Who hits ?), what would you answer ?' When one was certain that the child understood this part of the task, (s)he was told '...Sometimes, but not always, I will also show you a picture. I want you to look at it carefully. Sometimes, the picture will correctly depict what is said in the sentence, but at other times, it will show either the opposite of what is said in the sentence, or it will show something that has nothing to do with the sentence. First, you must remember the sentence in your head. The questions that I will be asking have always to do with the sentence, even if the picture shows something different from what is said in the sentence'. A demonstration followed. The test-sentences were produced by the experimenter with as neutral as possible an intonation in order to avoid cueing the child to the identity of the logical subject (LS) or the logical object (LO) (see Maratsos, 1973; Vion & Amy, 1984). The experimenter then presented a drawing to the child for five seconds (except in the Neutral situation where there was no drawing). Each test-sentence was followed by a

request to identify one of the two stated participants, either the LS or the LO. The request was in the form either of an active imperative Dis-moi qui (verbe) [Tell me who (verbs)] or of a passive imperative Dis-moi qui (est verbé) [Tell me who (is verbed)]. An oral repetition of the test-sentence by the experimenter followed the question. All the items were forced-choice. In case of doubt, the child was encouraged to make a 'best guess'. However (s)he was allowed to change her (his) mind. In such cases, only the last response produced was scored.

The two mental imagery tasks were presented next. Half of the subjects began with the mental rotation task, the other half with the mental reconstruction task. In the mental reconstruction task, the child was first presented with the reference card exhibiting geometrical forms and (s)he was requested to point to the correct solution. In order to familiarize the child with the task, two probe trials with concrete forms were given with the following instruction. 'Do you see this card (reference card pointed to by the experimenter) ? There are little drawings on it. I want you to think in your head. If one would put these drawings all together, what would that make ? Look at these three other drawings (target card and the two distractors). There is only one that corresponds exactly to the forms when they are put together. I want you to find it. Look carefully at all the pieces because everything has to be of the same size. Everything has to be the same as here (reference card). There is only one correct response'. If the child made a mistake in one of the probe trials, the experimenter demonstrated the correct solution and explained the task once again. Following the probe trials, the child was told that (s)he would not receive any more help. All the items were forced choice. When several answers were given, only the last one was taken into account for scoring.

In order to familiarize the subjects with the the mental rotation task, they were given two probe trials. (S)he was told 'I have drawn a pencil and rotated it. Here the pencil is pointing downward. Then it moves upward. If one rotated the pencil one more time, where would it be pointing to ?' The child had to choose between three possible solutions. If (s)he did not seem to understand the task, the experimenter gave the correct response and explained the task one more time. The child was told, then, that (s)he would not receive any further

information and the experimenter proceeded with the task.

RESULTS AND DISCUSSION

The number of correct responses given to the interpretive requests was the dependent variable. Verbs were not considered as levels of a random factor and were neglected in the analysis as, in order to perform statistical analysis, we collapsed into one score the two answers obtained in each of the 32 cells resulting from the crossing of the variables Actionality, Voice, and Situation (2 x 4 x 4) (the maximum score for each cell, therefore, was 2). With this procedure, the intra-cell variance is null. Means expressed as percentages are displayed in Table 1. In order to be able to use mental imagery performance as an independent variable in the analysis, we constructed the variable Imagery by summing up the scores obtained in the two mental imagery tasks. Each subject therefore received one single score for mental imagery. The subjects were distributed into 4 groups according to their performance in this respect : Group 1 (0 to 8 points; 10 subjects); Group 2 (9 to 10 points; 13 subjects); Group 3 (11 to 13 points; 13 subjects); or Group 4 (14 to 20 points; 12 subjects).

A five-way ANOVA with Age and Imagery as class variables, Voice, Actionality, and Situation as repeated measures variables, was carried out on the 32 scores obtained for each subject. Cells resulting from the crossing of the levels of the classificatory variables Age and Mental imagery contained unequal numbers of observations, as there were more younger subjects classified at lower levels of mental imagery and more older subjects at higher imagery levels. Consequently, in the ANOVA, the total variance was decomposed into Age variance and the Imagery variance, the latter being adjusted for age (Searle, 1987), in order to assess the effect of mental imagery, the age effect being eliminated.

For the variable Actionality, 71% correct responses was obtained for actionals while 61% correct responses was obtained for nonactionals. This difference proved significant : $F(1,36) = 44.85, p < .0001$. According to our hypothesis, we should obtain a significant interaction between Actionality and Imagery due to the increasing difference between actionals and nonactionals as the subjects' performance in the imagery tasks improves. As

expected, the Actionality x Imagery interaction proved significant; $F(9,36) = 3.54, p < .005$. Follow-up analyses (Newman-Keuls) revealed no significant contrast between any pair of means involved in the interaction. Here, one has to notice the shape of the interaction. Not only did the performance of visualizers compared to nonvisualizers increase with actionals (according to our theory, they allow for the construction of mental images), it decreased with nonactionals (they do not allow for the construction of mental images) (see Figure 1 for the Actionality x Imagery interaction).

INSERT FIGURE 1 HERE

The effect of the variable Voice was also significant : $F(3,108) = 17.78, p < .0001$. In this respect, the data confirm the hierarchy of difficulty illustrated in Rondal et al. (1990), i.e. Active-active : 75%, Active-passive : 71%, Passive-passive : 65%, and Passive-active : 55%. Follow-up analyses (Newman-Keuls) indicate that condition P/A differed significantly from conditions A/A and A/P ($p < .05$). Passive sentences were more difficult to understand no matter which voice is used in the interpretive request. The difficulty was greatest when the request is active. Further, the significant difference between the A/P and P/A conditions suggests that the feature passive renders comprehension more difficult, *ceteris paribus*, when it is located in the test-sentence rather than in the interpretive request.

The Actionality x Voice interaction was also significant : $F(3,108) = 4.94, p < .005$. Post hoc analyses revealed a significant difference between actionals and nonactionals only in the P/A (passive-active) condition ($p < .01$). When actionals were analyzed separately, no pair-wise comparison reached significance at any level of the variable Voice. When nonactionals were analyzed separately, the A/A, A/P, and P/P conditions differed significantly from the P/A condition ($p < .01$). Contrary to expectations based on Rondal et al.'s results (1990), no difference between actionals and nonactionals proved significant in the A/A condition. However, no differences proved significant in the A/P and P/P conditions despite the fact that in these conditions the test-sentences and/or the requests were in the

passive voice. This result suggests that the actionality effect may be more tied to the intrinsic difficulty of the task rather than to the passive voice per se. The only significant difference between actional and nonactional sentences appears in the P/A condition, the most difficult one, as suggested in the analysis of the effects of the variable Voice.

The main effect of the variable Situation was significant : $F(3,108) = 64.11, p < .0001$ (Neutral : 70%; Facilitative : 82%; Negative : 44%; Irrelevant : 70%). The Negative situation differed significantly from the other three situations ($p < .01$). The Actionality x Situation and the Situation x Voice interactions proved significant : $F(3,108) = 18.58, p < .0001$ and $F(3,108) = 3.44, p < .0005$, respectively. Particularly interesting is the triple interaction Actionality x Voice x Situation. This analysis should assess the difference between actionals and nonactionals at the different levels of the variable Voice within each level of the variable Situation. This interaction proved significant : $F(9,324) = 2.51, p < .01$. Follow-up analyses revealed that in the Neutral situation, actionals significantly differ from nonactionals in the P/A condition ($p < .01$); in the Facilitative situation, actionals differ from nonactionals in the A/P, P/P, and P/A conditions ($p < .01$); in the Negative situation, actionals differ from nonactionals in the A/A condition ($p < .05$) as well as in the P/P condition ($p < .01$). When actionals are analyzed separately, the Neutral situation differs from the Facilitative situation in the P/P condition ($p < .05$) and in the P/A condition ($p < .01$), whereas there is no significant difference between the Neutral situation and the Irrelevant situation on the four levels of the variable Voice; the Irrelevant situation differs from the Facilitative situation in the P/P and in the P/A conditions (both at $p < .01$); the Neutral situation, the Facilitative situation, and the Irrelevant situation differ from the Negative situation on the four levels of the variable Voice (all at $p < .01$). When nonactionals are analyzed separately, the Neutral situation differs from the Facilitative situation in the P/A condition ($p < .05$); the Neutral and the Irrelevant situations differ from the Negative situation in the P/A condition ($p < .05$ and $p < .01$, respectively); the Facilitative situation differs from the Negative situation in the A/A and the P/A conditions (both $p < .01$); and there is no significant difference between the Neutral situation and the Irrelevant situation on the four levels of the variable Voice (see Table 1 and Figures 2 and 3).

INSERT FIGURES 2 AND 3 HERE

The relationship between actionality effect and hierarchy of difficulty defined above for the variable Voice can be illustrated more precisely. In the Neutral situation, the only significant difference between actionals and nonactionals appears in the most difficult condition (i.e. P/A); in the Facilitative situation, the significant differences appear in the two most difficult conditions (P/A and P/P). These results confirm the hypothesized link between the actionality effect and task difficulty. In the Negative situation, nonactionals are better understood than actionals (i.e. a nonactionality effect !) in the A/A and in the P/P conditions (see below for a further analysis of these data). In the Irrelevant situation, no difference between actionals and nonactionals reaches statistical significance. The reversal of the actionality effect in the Negative situation and the absence of actionality effect in the Irrelevant situation suggest that this effect is not necessarily linked to the passive voice. Post-hoc analyses of the three-way interaction also indicate that when two levels of the variable Situation are compared for actionals only at the four levels of the variable Voice, they differ more frequently than when the same comparison is made for nonactionals (16 significant differences vs 5). In other words, a change in the pictorial material has a greater effect on performance in the case of actional sentences. For example, the Neutral and the Negative situations significantly differ one from the other at the four levels of the variable Voice for actionals, whereas only one corresponding difference is significant for nonactionals (i.e. in the P/A condition). This result is compatible with the hypothesis of a significant role of mental imagery in sentence interpretation. It suggests that opposite drawings interfere less with the subjects' treatment of the test-sentences and the interpretive requests in those cases where the formation of a mental image is not possible or is more difficult, i.e. with nonactionals (see below).

INSERT TABLE 1 HERE

Syntactic markers and the demonstration of the actionality effect

In order to explain the actionality effect fully, one has to consider the interactions between the Actionality variable and the other variables in the sentences presented in the comprehension task. We have shown that the passive feature alone is not sufficient for obtaining a significant actionality effect. Leaving aside pragmatics, subjects may rely on semantic and syntactic information in order to comply with the interpretive requests⁴. Tasks that render syntactic markers more difficult to operate upon could possibly favor the intervention of variables such as actionality or reversibility (see Bever 1970; Sinclair & Ferreiro, 1970). Similarly, if a child does not fully master the syntactic cues, verb actionality and propositional nonreversibility (for example) can be of help in decoding the sentence and answering questions bearing on its meaning. If one considers the syntactic cues involved in the four conditions of increasing difficulty (A/A, A/P, P/P, P/A) defining the variable Voice in the above experiment, one could argue that the A/A and the A/P conditions are relatively easier because, as the child masters the active voice, (s)he can build a mental representation of the test-sentences in order to answer questions. In the P/P and the P/A conditions, children who do not completely master the passive cues (see Sudhalter & Braine, 1985) will have difficulty in building a mental representation of the sentences and henceforth to answer questions bearing on them. The A/P and the P/A conditions are more difficult than the A/A and P/P conditions, respectively, because the questions are formulated in the opposite voice compared to the sentence voice. Observations by Thibaut (1993), demonstrating an actionality effect in a comprehension task containing active sentences with a relative subordinate (introduced by the relative pronoun qui (who)) with children aged 5;0 to 9;0, suggest that one cannot reduce the actionality effect to the presence of a syntactic marker whatever it is. Thibaut used sentences with an embedded relative clause or a relative clause derived on the right. He observed a significant interaction between Actionality and Embeddeness, indicating that the actionality effect is observed in sentences with relative clause derived on the right only. This result, which generalizes the actionality effect to active sentences (confirming Rondal et al., 1990), suggests that one needs to consider the procedural

aspects involved in the treatment of each linguistic structure and, particularly, the interactions between the different variables involved in the sentences used in a given experiment.

Mental imagery and the actionality effect

In the introduction, we hypothesized that the actionality effect can be described in terms of mental imagery. We believe that our results are compatible with the hypothesis that mental imagery plays a significant role during the receptive analysis of the test-sentences and/or in the elaboration of the responses to the interpretive requests. The major point in this discussion is the significant interaction between Imagery and Actionality revealing that visualizers, compared with non-visualizers, demonstrated better performance with actionals and worse performance with nonactionals. Also, the difference between actionals and nonactionals is reversed in the Negative situation, which we take to be a sign of a conflict between the mental image formed by the subjects and the external image presented by the experimenter. Else, no significant four-way interaction of Imagery, Actionality, Voice, and Situation was observed. The augmented difference between actionals and nonactionals tied to an increase in the subjects' performance on the mental imagery tasks is stable no matter what the voice or the situation (see below).

One can conceive of the role of mental imagery in sentence processing in various ways. According to some authors (e.g. Denis, 1989), the mental image supplies the subject with different information compared to that provided in the meaning of the sentence. The role of the image in the comprehension process is localized at a different 'mental level' from the semantic treatment of the sentence (Denis, 1989). Such a conception implies two processing steps : firstly, the semantic treatment of the sentence yields a semantic representation; secondly, the subject uses mental imagery to represent the meaning relationship expressed in the sentence in an analogical manner. It is assumed that the mental images formed do not add anything important to the semantic representation itself. According to the proponents of the dual-coding theory (e.g. Paivio, 1986), the treatment of a concrete sentence is more closely associated with the use of mental images than the treatment of abstract sentences. For example, a sentence such as The boy hits the girl usually leads to

the elaboration of a mental image correctly figuring the action taking place between two persons. It is also claimed that there is a qualitative difference between the memory trace of a concrete sentence and the trace of an abstract sentence. But the dual-coding theory does not specify the exact relationship between the image and the semantics of the sentence.

Both the above theoretical positions regarding the possible role of mental imagery in sentence processing are compatible with our results. According to the first point of view, the image complementing the meaning of the sentence is formed after the sentence has been understood and it may serve as an anchoring point for the possible reprocessing of the sentence brought about by the interpretive request. The mental image helps to sustain the semantic representation constructed from the sentence. The implication is that the actionality effect is not tied to the comprehension of the test-sentence itself, but rather to the reprocessing of its contents which have to have been understood first.

The dual-coding theory is consistent with two possibilities : either (a) image construction is a process separate from sentence comprehension. In this case, the role of the image, if any, is temporally located at the moment of the answer to the interpretive request, or (b) the mental image is constructed on-line and this construction helps the subject to organize the semantics of the sentence. The explanation of the actionality effect will vary depending on the point of view that one adopts. In the first view, the actionality effect is not tied to sentence processing but to subsequent reprocessing when a question is asked. In the second view, on the contrary, the actionality affect is considered to be tied to the elaboration of the meaning of the sentence and contributes to the comprehension process. Glass, Millen, Beck, & Eddy (1985) have suggested that mental imagery plays a significant role beyond the comprehension process itself, whenever subjects have to deal with the meaning of the sentence (for example, verifying its truth-value). In any case, results such as Glass et al.'s suggest that the mental image helps subjects at the moment when answering the interpretive request. But it is also plausible that the subjects (or, at least, some subjects) use mental imagery as a help in the comprehension process itself, as more imageable referents may better contribute to the construction of a representation of the semantic relations referred to in the sentences.

Returning to the data presented above, one might argue that our hypothesis concerning the role of mental imagery implies the existence of a significant interaction between Imagery, Actionality, and Situation, which was not observed in the data. Indeed, it could have been expected that visualizers would have exhibited a marked decrease in their performance on the actionals in the Negative situation, since the drawings presented in this situation represented the reverse of what was specified in the sentence. Consistently, nonvisualizers, not resorting or resorting less to mental imagery, would not have demonstrated such a decrease in performance in the same situation, leading to the expected three-way interaction. The results did not conform to this expectation. As the absence of interaction indicates, the subjects' performance (visualizers as well as nonvisualizers) with actionals did not differ in the Negative situation from other situations, i.e. it tended to be better with actionals and worse with nonactionals in proportion to the subjects' imagery capacity. The explanation for the absence of three-way interaction rests on the results obtained in the Negative situation, in which nonactionals were better understood than actionals. Nonvisualizers obtained 25% of correct answers with actionals and 51% with nonactionals, whereas the corresponding mean scores for visualizers were 55% and 43%, respectively. The difference between visualizers and nonvisualizers with the actional sentences was more marked in the Negative situation (30%) than in the other situations (20% or less). This result is consistent with our hypothesis about the role of mental imagery. It also reveals something interesting about the subjects' processing of the test-sentences and the interpretive requests. Visualizers elaborate a mental image during and/or after having heard the sentence. When they are confronted with a picture contradicting their mental representation, visualizers either notice the difference between their representation and the picture or they do not. But, as they have already constructed a mental representation of the sentence, they can use it without being disturbed by the content of the drawing. When presented with a sentence, nonvisualizers tend not to construct a mental image. They may be more inclined to use the picture in order to answer any interpretive request. Consequently, their performance with actionals tends to be worse in comparison to visualizers when the pictures incorrectly depict the thematic meaning of the sentences, as was the case with our

Negative situation.

The above analysis suggests that mental imagery is a plausible support for sentence processing in comprehension tasks. It may play such a role within the functional framework of working memory (e.g. Baddeley, 1990). All comprehension tasks involve a short-term-memory component to the extent that in order to answer a question on a given sentence, the latter must have been previously stored either verbatim or its meaning. The memory trace is operated upon by the subject in order to answer the question. This operation may prove easier when a mental image is available. Data obtained by Lempert & Kinsbourne (1981) are congruent with our proposal. These authors compared the retention in memory of three types of verbal stimuli : a) actional SVO sentences; b) nonactional SVO sentences; and c) pairs of terms composed of the grammatical subject and the grammatical object from the actional and nonactional sentences used in the other two conditions. The subjects' performance was much better with the actional sentences than in the other two conditions which did not significantly differ one from other. This result is consistent with the notion that actional verbs may play the role of linking elements in the construction of unified mental images corresponding to the thematic meaning of the sentences. It has been shown (e.g. Bower, 1972) that when an experimenter suggests to his/her subjects to create a mental image representing the referents of a pair of words, they retain these words in memory better. It is likely that when actional verbs are used, subjects, particularly visualizers, tend to use spontaneously such an image formation strategy.

One could ask whether the effect of mental imagery is related to general cognitive development, or whether it is specifically tied to individual (possibly typological) differences in the capacity to form mental images. In the literature (see Dean, 1990, for a comprehensive review and a discussion), there are several models of the relationship between cognitive development and the development of mental imagery capacity. These models go from complete independency (sometimes with the additional hypothesis that mental imagery corresponds to a set of innately determined modular processes) to total relatedness between the two types of development. Our data are supportive of the former suggestion. As indicated above, the analysis of the subjects' responses performed with the variable Imagery

adjusted for Age shows that the imagery effect is not simply a consequence of general development. Additionally, the significant Imagery x Actionality interaction effect observed in our data is not compatible with a general effect of cognitive development because the performance in comprehension for actionals increased in proportion to the increase in imagery, whereas performance for nonactionals decreased for subjects with better imagery capacities. If the increase in imagery were linked to an increase in intellectual efficiency, the subjects' performance on nonactional sentences should have increased slightly together with an augmented mental imagery capacity, whereas the subjects' performance on actionals should have increased in a more marked way together with a more efficient use of mental images. This was not observed in our data.

What about other theoretical accounts of the actionality effect ? Sudhalter & Braine (1985) suggested that the different pieces of knowledge involved in the passive (such as the 'be-en' and 'by' forms) are not mastered simultaneously by children. In that view, passive sentences should be interpreted erratically for some time by children. It is also possible, however, that the children (particularly younger ones) do know a good deal about the passive cues but that their processing in this respect has to be supported somehow in order to be fully efficient. A figurative mental representation of the sentence meaning may play this supportive role. The same reasoning can be applied to the verb-based approach developed by Gordon & Chafetz (1990), which suggests that passives are learned verb by verb. With respect to our experiment, and if a verb-based approach were correct, the same results should have been obtained across conditions and situations in which the passive voice was used. Such a consistent trend did not occur. Furthermore, data obtained by Thibaut (1993), revealing an actionality effect in active sentences with non-embedded relative clauses, are not congruent with a verb-based approach. Lastly, Maratsos et al. (1985) proposed that semantic transitivity could explain the difference in the children's treatment of actional and nonactional sentences. Restricting the actionality effect to prototypical semantic role such as agent and patient is not empirically correct. One must take into account the fact that the actions referred to by actionals are potentially more prone to producing an image than the events referred to by nonactionals. In our Negative situation, nonactional sentences were better

understood than actional ones in spite of the fact that, in this situation, the semantic roles were exactly the same as the ones in other situations (e.g. Facilitative, Neutral) where actionals were better understood than nonactionals.

In conclusion, previous authors have claimed that the actionality effect is restricted to the passive structure and that it appears in all experimental conditions. We have shown that the actionality effect is not limited to the passive and that it does not appear in all experimental conditions.

NOTES

1. Maratsos et al. (1979) explicitly reject the hypothesis of a ceiling effect on the actives that would have masked the presence of an actionality effect in this voice. They analyse the results of those of their subjects presenting at least one error in six questions. No actionality effect appears in the results. This reasoning is not convincing, however. If the actionality effect is linked to given characteristics of the task, eliminating the best performing subjects does not change these characteristics. A lesser efficiency with the task in some subjects may not necessarily result from the use of a different response strategy relating to the actionality effect itself. It may have to do with possible confounding variables such as high motivation, better concentration on the task, intellectual ability, etc.
2. A post-hoc test on this interaction revealed that the difference between actional and nonactional active sentences with active interpretive requests is significant.
3. This example as well as the following ones in text (for the test sentences as well as for the interpretive requests) are literal translation from French to English. They do not express the progressive aspectual marking that is standard in corresponding English sentences.
4. The absence of an actionality effect in a production task, as reported by Pinker, Lebeaux, & Frost (1987), can be easily explained in this context. In a production task, subjects only deal with the sentences that they construct and there is no setting of any specific relationship between the sentence produced and a possible question. This remark does not imply that it should be impossible to demonstrate actionality effects in sentence production.

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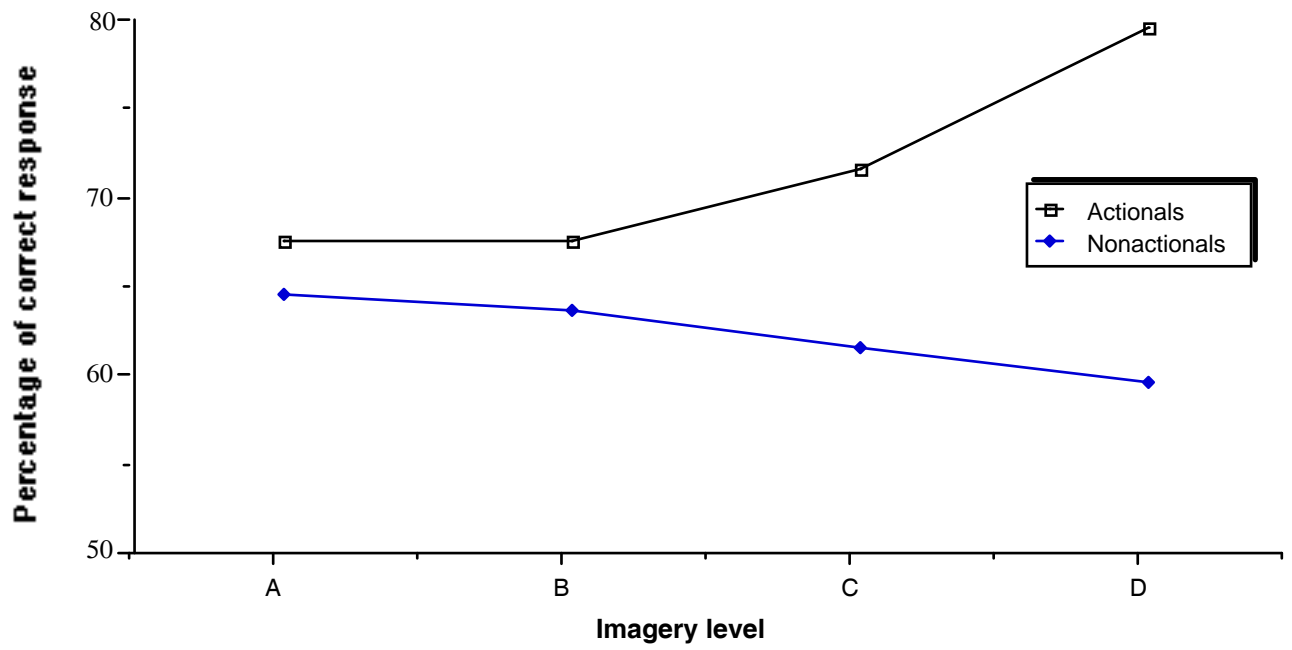
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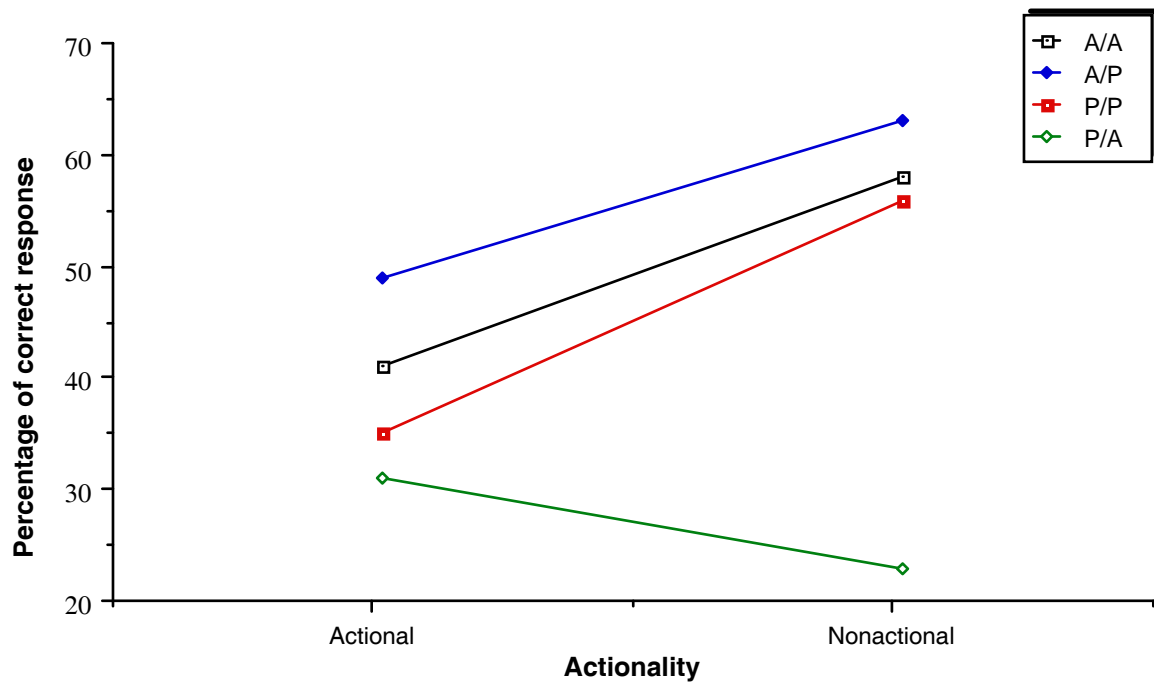
Table 1. Percentage of correct responses as a function of Voice, Situation, and Actionality.

| Voice ^a | SITUATION | | | | <i>Mean</i> |
|-----------------------|-----------|--------------|-----------|------------|-------------|
| | Neutral | Facilitative | Negative | Irrelevant | |
| Actional sentences | | | | | |
| Active-Active | 91 | 93 | 40 | 79 | 76 |
| Active-Passive | 79 | 94 | 48 | 82 | 76 |
| Passive-passive | 74 | 94 | 34 | 69 | 68 |
| Passive-active | 71 | 94 | 30 | 68 | 66 |
| <i>Mean</i> | <i>79</i> | <i>94</i> | <i>38</i> | <i>75</i> | <i>72</i> |
| Nonactional sentences | | | | | |
| Active-Active | 76 | 91 | 57 | 74 | 75 |
| Active-Passive | 58 | 70 | 62 | 69 | 65 |
| Passive-passive | 68 | 59 | 55 | 66 | 62 |
| Passive-active | 43 | 63 | 22 | 51 | 45 |
| <i>Mean</i> | <i>61</i> | <i>71</i> | <i>49</i> | <i>65</i> | <i>62</i> |
| <i>General Mean</i> | <i>70</i> | <i>83</i> | <i>44</i> | <i>70</i> | <i>67</i> |

Note^a The first element in the pair refers to the voice of the sentence; the second element in the pair refers to the voice of the interpretive request.

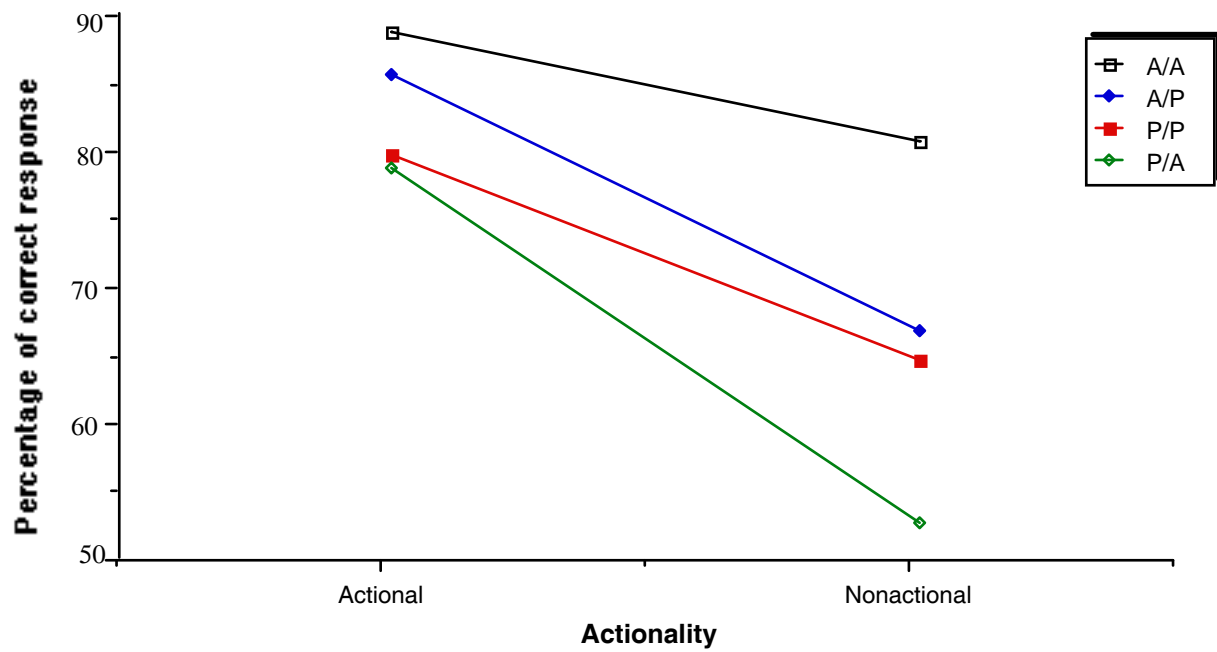
Figure 1 Interaction between Actionality and Imagery ^a

^a Subjects were classified into groups of estimated increasing imagery capacity from A to D.

Figure 2 Interaction between Actionality and Voice (negative situation) ^a

^a A/A Active-Active situation; A/P Active-Passive situation; P/P Passive/Passive situation; P/A Passive/Active situation.

Figure 3 Interaction between Actionality and Voice (Neutral, Facilitative, Irrelevant situations) ^a



^a A/A Active-Active situation; A/P Active-Passive situation; P/P Passive/Passive situation; P/A Passive/Active situation.

APPENDIX 1 : List of sentences used in the A/A condition

1. Le monsieur frappe la dame (The man hits the woman). Ac1-Neutral situation
2. La maman tient le papa (The mother holds the father). Ac2-Neutral situation
3. L'oncle admire la tante (The uncle admires the aunt). NAc1-Neutral situation
4. La cousine imagine le cousin (The cousin imagines the cousin).NAc2-Neutral situation
5. Le garçon coiffe la fille (The boy combs the girl). Ac3-Facilitative situation
6. La fille lave le garçon (The girl washes the boy). Ac4-Facilitative situation
7. La fille aime le garçon (The girl loves the boy). NAc3-Facilitative situation
8. Le garçon voit la fille (The boy sees the girl). NAc4-Facilitative situation
9. La fille porte le garçon (The girl carries the boy). Ac5-Negative situation
10. Le garçon pousse la fille (The boy pushes the girl). Ac6-Negative situation
11. Le garçon déteste la fille (The boy hates the girl). NAc5-Negative situation
12. La fille attend le garçon (The girl waits for the boy). NAc6-Negative situation
13. Le garçon mord la fille (The boy bites the girl). Ac7-Irrelevant situation
14. La fille renverse le garçon (The girl turns over the boy). Ac8-Irrelevant situation
15. La fille oublie le garçon (The girl forgets the boy). NAc7-Irrelevant situation
16. Le garçon entend la fille (The boy hears the girl). NAc8-Irrelevant situation