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SHORT PAPER

The effect of aging on facial prototype formation

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Abstract

Young and elderly subjects performed a recognition task on unfamiliar faces which were variations of a non-inspected prototype (procedure designed by Solso and McCarthy, 1981a). The test was taken immediately or six weeks later. Young subjects (n = 32) clearly replicated the performance of the Solso and McCarthy subjects, namely, very confident (false) recognition of the prototype and correct rejection of new stimuli in accordance with their similarity to the prototype. In addition, the results showed a strong analogy between elderly and young subjects. In particular, elderly subjects (n = 32) abstracted the never-seen prototype as well as younger subjects, even after six weeks. However, they were significantly less confident in rejecting new items.

Key words: Aging, prototype, faces.

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INTRODUCTION

It is well-documented that older adults perform poorly on explicit memory tests, such as recall or recognition, which require deliberate recollection of specific episodes (for reviews, see Kausler, 1994; Van der Linden, 1994). However, not all aspects of memory function show inexorable decline. When younger and older adults are compared on implicit memory tasks (which do not involve deliberate recollection), age differences are generally small and unreliable (for a review see Light, 1991).

Other studies have found that there are few age differences in the ability to abstract central tendency information from a set of visual stimuli. This was in spite of the fact that the older adults exhibited poorer memory for individual stimuli (Hess, 1982; Hess & Slaughter, 1986a, 1986b). This preserved ability to develop category-level knowledge in the absence of memory for individual items has also been observed in amnesic patients (e.g., Knowlton & Squire, 1993; Kolodny, 1994; Lories, Van der Linden, & Cornille, 1994; Van der Linden, Lories, & Cornille, 1993).

The present study further examines the effects of aging on the abstraction of the prototype in the domain of face memory. Age differences in memory for pictures of faces have been observed in a series of papers (e.g., Crook & Larrabee, 1992; Ferris, Crook, Clark, McCarthy & Rae, 1980; Mason, 1986; Smith & Winograd, 1978). Moreover, it appears that there are few age differences in hit rates for correctly recognizing old faces but a large age difference in false alarm rates for incorrectly recognizing new faces as old (Bartlett & Fulton, 1991; Bartlett, Strater, & Fulton, 1991; Fulton & Bartlett, 1991). Bartlett and his collaborators interpreted these results by suggesting that elderly subjects making recognition decisions rely more on perceived familiarity and less on recollection of context.

Face prototype formation has already been explored in young adults, especially by Solso and McCarthy (1981a). In their study, young adult subjects inspected faces which were variations of a non-inspected prototype, and then had to recognize them in a set including the prototype. The major result was that the prototype was erroneously recognized as an "old" figure with a high level of confidence, and that this effect held for both immediate and delayed (six week) recognition. Another result was that correct rejections of new stimuli were affected by their similarity to the prototype. Finally, accuracy was good. Similar results have been observed with other types of stimuli, such as geometric forms (Franks & Bransford, 1971) or three-digit numbers (Solso & McCarthy, 1981b). These studies indicate that when subjects study a list of items, they not only learn about the specific exemplars but they also store common features from exemplars. More recently Inn, Walden, and Solso (1993) examined facial prototype formation in children between the ages of 3 and 6. They showed that the number of false alarms on the prototype increased from the younger to the older group, with 6-year-olds' responses to the prototype being similar to adult performance.

The aim of this study was to determine whether elderly subjects still have the ability to abstract frequently experienced facial features and retain some form of that information. The procedure was similar to the one designed by Solso and McCarthy (1981a). Young and elderly subjects first inspected a series of ten faces, all variations of a non-inspected prototype. Then they had to recognize four of the inspected faces (targets) in a series of ten, and to indicate their level of confidence. The six new faces (distractors) were also variations of the prototype with a percentage of features in common with the prototype ranging from 0 to 100 (the prototype itself). Thus, the items were a within-subject variable. Four between-subject variables were controlled and fully combined, namely, age (old vs. young), gender, testing time (immediate vs. delayed), and stimulus (four different sets of stimuli, each having its own prototype, were employed to avoid idiosyncratic effects of the faces themselves).

METHOD

Subjects

Thirty-two young and 32 elderly subjects participated. The young subjects were students at Louvain-la-Neuve University. They were between 18 and 24 years old (mean age = 21.66). The elderly subjects were between 59 and 71 years old (mean age = 62.19). They were healthy individuals living in the community with at least nine years of education. In each sample, the subjects were randomly assigned to the immediate or the delayed test condition, with eight women and eight men in each subgroup. The two subgroups did not differ in age (young: $t(30) = .262$, NS; elderly: $t(30) = .442$, NS).

To measure crystallized verbal ability, each subject was administered the Mill-Hill Vocabulary Scale (French translation by Deltour, 1993). The individual scores (out of 34) were examined by means of an anal-

ysis of variance (ANOVA) involving the two between-subject factors defining the four experimental subgroups, i.e., age and delay. The ANOVA showed that the subjects were equally distributed (on this measure) across the various subgroups, since no significant effect emerged (all $Fs < 1$).

Stimuli

Using the "Mac-a-Mug Pro" program for Macintosh, 64 different faces with seven features each were drawn and printed on paper. There were four subsets of 16. In each subset, 15 faces were identical as to the ears, chin, and eyebrows; the sixteenth differed from the other 15 on all features. Among the 15 faces, one was the prototype and the remaining 14 were variations of it made by manipulating the hair, eyes, mouth, and/or nose. These 14 stimuli were drawn as follows. Four faces shared three of the four critical features of the prototype (75%), six shared two critical features (50%), and four shared one critical feature (25%). Within each subset of four or six faces, the manipulated features varied randomly from face to face, each feature being represented equally.

Experimental design and procedure

After the completion of the Mill-Hill vocabulary test, the study phase of the experiment started. The subject was shown ten targets one by one, for ten seconds each, and asked to inspect them carefully so as to be able to recognize them later. The targets (randomly distributed) were three 75% faces, four 50% faces, and three 25% faces.

For the test phase, the subjects were shown ten faces in random order. They had to make an old/new decision on each face, without time pressure, and to indicate their level of confidence on a five-point scale (procedure used by Solso and McCarthy, 1981a). These ten faces were the prototype (100% new: 100N), one old (target), and one new 75% face (75T and 75N), two old and two new 50% faces (50T and 50N), one old and one new 25% face (25T and 25N), and one entirely new face (0N). The old faces were identical to the faces displayed in the study phase. For half of the subjects in each age group, the test was administered five minutes after the inspection stage (immediate testing condition); the five minutes were filled by a letter cancellation task. For the other half, the test was administered six weeks later (delayed testing condition).

RESULTS

The subjects' responses, including their level of confidence, were studied as a function of the kind of face. The raw data were the degrees of confidence (1-5) associated with a positive sign for accepts ("old" decisions) and a negative sign for rejects ("new" decisions). Figure 1 shows the mean results.

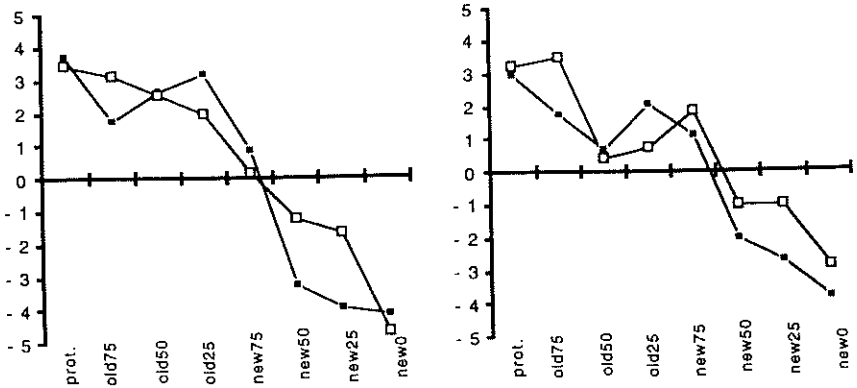

Figure 1. Signed confidence ratings of the young (black symbols) and elderly subjects (white symbols) as a function of the testing time (left panel: immediate, right panel: delayed). The prototype label ("prot.") refers to the new 100% face.

1) The first ANOVA was computed with age and testing time as the between-subject factors, and the kind of item (old vs. new) and face typicality (75 vs. 50 vs. 25%) as the within-subject factors. The prototype and the 0N face were not included in the first analysis. The sole sign of an effect of the testing time appeared in the significant interaction between the kind of stimulus and the testing time, $F(1, 60) = 4.927$, $p < .035$. The post-hoc analysis of this interaction revealed a significantly higher level of confidence in the immediate rather than delayed testing condition for old faces, $F(1, 62) = 4.023$, $p < .05$, and no effect of the testing time for new faces, $F(1, 62) = 2.37$, NS.

There was also a trend towards a main age effect favoring young over elderly subjects, $F(1, 60) = 3.564$, $p < .064$, a significant effect of

the kind of stimulus, $F(1, 60) = 53.448$, $p < .0001$, and a significant effect of face typicality, $F(2, 120) = 24.146$, $p < .0001$. However, they were underpinned by a significant kind-of-stimulus by face-typicality interaction, $F(2, 120) = 6.696$, $p < .002$, and a significant age by kind-of-stimulus by face-typicality interaction, $F(2, 120) = 4.848$, $p < .01$. The post-hoc analysis of the last interaction revealed three findings.

(a) There was a significant effect of age for the 25N ($F(1, 62) = 5.513$, $p < .025$), 50N, ($F(1, 62) = 5.677$, $p < .02$), and 75O faces ($F(1, 62) = 4.381$, $p < .041$); the young were more confident than the elderly subjects in the rejection of the 25N and 50N faces, but less confident than elderly subjects in the recognition of 75O faces. However, for the three levels of typicality pooled, it should be noted that young and elderly subjects did not clearly differ in the recognition of old faces (2.021 vs. 2.063), while young subjects rejected new faces more confidently than elderly subjects (-1.646 vs. -0.464).

(b) The kind-of-stimulus by face-typicality ANOVA for young subjects revealed significant main effects of face typicality, $F(2, 62) = 11.928$, $p < .0001$, and kind of stimulus, $F(1, 31) = 37.162$, $p < .0001$: young subjects were more confident in responding to 75% than to 50% and 25% faces, and they discriminated the old faces from the new, but were more confident in the recognition of old faces than in the rejection of new ones (2.021 vs. -1.646). However, the kind-of-stimulus by face-typicality interaction was significant, $F(2, 62) = 12.538$, $p < .0001$: old and new 50% and 25% faces were clearly discriminated (50O = 1.69, 50N = -2.62, 25O = 2.62, 50N = -3.31), whereas this did not apply to 75% faces (75O = 1.75, 75N = 1.00).

(c) The kind-of-stimulus by face-typicality ANOVA for elderly subjects yielded a significant main effect of face typicality, $F(2, 62) = 12.144$, $p < .0001$, and kind of stimulus, $F(1, 31) = 16.377$, $p < .0003$: elderly subjects were more confident in responding to 75% than to 50% and 25% faces, and they discriminated the old faces from the new but were not very confident in rejecting new faces (2.063 vs. -0.464). However, unlike the young subjects, the kind-of-stimulus by face-typicality interaction was not significant in the elderly ($F < 1$, NS).

2) The responses to new faces were studied by means of a second ANOVA with age and testing time as the between-subject factors and face typicality (100 vs. 75 vs. 50 vs. 25 vs. 0%) as the within-subject factor. The main age effect was significant, $F(1, 60) = 4.318$, $p < .045$, showing that young subjects were more confident than the elderly. There was a tendency toward a higher confidence level in the immediate than in the delayed condition, $F(1, 60) = 3.231$, $p < .077$. There was also a significant effect of face typicality, $F(4, 240) = 63.88$, $p < .0001$: the expected gradient was found (see Figure 1), since all differences were significant (except between 50N and 25N faces which was nevertheless in the predicted direction). Note that the prototype was confidently "recognized" (actually, a false alarm) and that the 75N face tended to be "recognized" too (a positive mean value).

3) For both testing times pooled, 28 young and 29 elderly subjects out of 32 erroneously "recognized" the never-seen-before prototype, an obviously nonsignificant age effect, $\chi^2(1) = 0$, NS. For the three levels of typicality pooled, the proportion of correct recognitions of old faces (hits) was .711 in young subjects and .711 in elderly subjects, another obviously nonsignificant age effect, $t(62) = 0$, NS. For the five levels of typicality pooled, the proportion of erroneous recognitions of new faces (false alarms) was .425 in young subjects and .538 in the elderly, $t(62) = 2.112$, $p < .04$.

DISCUSSION

Firstly, the pattern of results for young subjects closely replicated that of the young subjects in the Solso and McCarthy (1981a) study. On the one hand, the subjects displayed obvious and confident "recognition" of the never-seen-before prototype. On the other hand, the rate of correct rejection of new stimuli depended on their degree of similarity with the prototype (the 75% new item tended even to be erroneously recognized, with a mean positive value). Finally, the recognition of faces in the delayed condition was nearly identical to that observed in the immediate condition. This surprising result was also obtained by Solso and McCarthy (1981a) and seems to confirm the well-known robustness of face memory over time (e.g., Bahrick, Bahrick, & Wittlinger, 1975).

Secondly, the pattern of results displayed by elderly subjects was close to that shown by young subjects. Two comments are called for here. On the one hand, "recognition" of the prototype was unaffected by age. Obviously, elderly subjects were able to abstract the never-seen-before prototype, or central tendency, from a set of displayed exemplars, and they did so as well as younger subjects, even when a long delay was introduced. Thus, the present study showed that a phenomenon already obtained with other visual materials (Hess, 1982; Hess &

Slaughter, 1986a, 1986b) also applies to faces. In support of this generalization to faces, we might mention the results of a second experiment not reported here in detail. Different samples of 32 young and 32 elderly subjects were enrolled for this experiment, but the faces were displayed upside down in the test phase. Roughtly speaking, the results were largely consistent with those of the present study, which indicates that the reported effects are probably not specific to faces. On the other hand, regarding the recognition of individual exemplars, there was no age effect in the recognition of old faces (with one exception: the elderly were more confident than young subjects in recognizing 75O faces). However, the elderly subjects were less confident and produced more false alarms on new items than did young subjects. Generally, these results seem to be consistent with Bartlett et al.'s hypothesis according to which older subjects are deficient in recollecting contextual information, so they rely heavily on resemblance information in recognizing faces (Bartlett et al., 1991). In other words, older subjects are thought to use schematic memory or context-free familiarity as the basis of recognition judgements rather than specific memory.

The status of this schematic face that both young and elderly subjects misidentified with high confidence as a formerly seen face remains to be examined. Two different conceptions can account for the kind of memory involved in the acquisition of category-level knowledge. One view suggests that this knowledge is acquired in the form of prototypes which are represented separately from knowledge about the studied exemplars (for faces, see Valentine, 1991). However, according to some authors, the prototype is the central point of a multidimensional space where the means of the distances along all attribute dimensions of the exemplars intersect (a central tendency model: Posner & Keele, 1968), while for others, the prototype is a pattern incorporating the most frequently encountered features (attributes) of a set of exemplars (a frequency model: Neumann, 1974). This view is well supported by studies conducted on amnesic patients which show that category-level knowledge can be learned in spite of severe memory deficits for exemplars presented during learning (e.g., Knowlton & Squire, 1993; Kolodny, 1994; Van der Linden et al., 1993). In such a theoretical framework, preservation of categorization in elderly subjects should be interpreted by postulating that the memory system responsible for the processing of abstract categorical information is not affected by aging.

The second view is that category-level information is not represented in a memory system different from that which stc : the exemplars. Rather, categories emerge from exemplar memory and a novel item is

thought to be categorized as a function of its similarity with the already stored exemplars of that category (e.g., Hintzman, 1986; McClelland & Rumelhart, 1985; Nosofsky, 1986, 1988). In this perspective, one might assume that although most traces for specific exemplars are relatively weak in elderly subjects, a kind of conspiracy effect among specific exemplar traces allows them to falsely recognize the prototype in a way similar to younger subjects.

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RÉSUMÉ

Des adultes jeunes et âgés ont accompli une tâche de reconnaissance épisodique de visages non familiers qui étaient des variations d'un prototype non présenté à l'encodage (une procédure mise au point par Solso et McCarthy, 1981a). Le test de reconnaissance avait lieu immédiatement ou après un délai de six semaines. Les sujets jeunes (n = 32) ont clairement reproduit les performances de ceux de Solso et McCarthy, à savoir une (fausse) reconnaissance du prototype sous un degré élevé de confiance, et un rejet correct des visages nouveaux qui dépendait de leur similitude par rapport au prototype. En outre, les résultats ont montré une profonde analogie entre les performances des sujets âgés (n = 32) et celles des sujets jeunes. En particulier, les personnes âgées étaient capables d'abstraire le prototype jamais vu aussi bien que les jeunes, même lorsqu'un long délai était introduit. Cependant, ils étaient moins confiants que les jeunes dans leurs rejets des visages nouveaux.

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