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Humor processing, mentalizing, and executive function in normal aging

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Abstract

Recent investigations have emphasized the importance of the prefrontal cortex for humor processing. Although the prefrontal cortex is thought to be affected by normal aging, relatively little work has been carried out to investigate the effects of aging on humor processing. In the present investigation participants in three age groups were assessed on a humor comprehension task. They then answered mentalistic and nonmentalistic questions. Executive tasks were also administered. The older group selected significantly fewer correct punchlines from alternatives than the other groups. They were also poorer at answering mentalistic questions, but did not differ significantly for nonmentalistic questions. The findings of the present investigation showed altered in humor processing in normal aging, and this appeared to be related to mentalizing ability. (*JINS*, 2006, *12*, 184–191.)

Keywords: Theory of mind, Mentalizing, Cognitive, Development, Social cognition, Incongruity, Resolution

INTRODUCTION

Despite its important role in human social interaction, only a few neuropsychological investigations on humor processing exist. Studies conducted so far have been mainly based on the incongruity resolution theory (Suls, 1972). Incongruity resolution theory proposes two stages of humor processing. The first stage (incongruity detection) refers to the perception of an incongruous element, which is resolved in the second stage (resolution).

Early studies have compared patients with damage to the right hemisphere (RHD) with healthy controls on a humor processing task (Wapner et al., 1981; Brownell et al., 1983) In these studies, joke stems with different alternative endings were presented and patients and healthy controls were instructed to select the correct funny punchline. In an extension of these studies Bihrle et al. (1986) investigated the differential contribution of the left and right hemisphere to the two stages of incongruity resolution theory. In this study the verbal joke stimuli from Brownell et al. (1983), as well as captionless cartoons, were presented to RHD patients. In addition, the cartoons were presented to patients with damage to the left hemisphere (LHD). While both patient groups were impaired, they showed a differential pattern of errors. RHD patients mostly chose nonsensical endings that involved detection of an incongruent element, but no resolution of this incongruity. LHD patients were mainly attracted to straightforward endings that were congruent in the story context, but did not involve incongruity, that is, were not funny. The findings have therefore been interpreted as support for a differential contribution of the two hemispheres, with the right hemisphere being engaged in incongruity resolution and the left hemisphere supporting incongruity detection.

In a more recent investigation by Shammi and Stuss (1999), a paradigm similar to that of Brownell et al. (1983) was used. In contrast to previous studies, funniness ratings were also assessed. The results suggested a predominant role of the right frontal cortex in humor processing. Shammi and Stuss (1999) reported that patients with lesions to the right frontal cortex showed deficits in selecting the correct funny punchline. They showed reduced funniness ratings and typically selected nonsensical endings. In a recent functional imaging study (Goel & Dolan, 2001), activation in response to jokes rated as funny was compared to activation for nonfunny jokes on a participant-by-participant and

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joke-by-joke basis. Activations were observed in the medial ventral prefrontal cortex and bilaterally in the cerebellum. Since the activation of medial ventral prefrontal cortex also covaried with participants' post-scan ratings of joke funniness, Goel and Dolan (2001) concluded that this region is part of a network involved in processing the affective component of humor.

The "frontal aging hypothesis" suggests that the prefrontal cortex is particularly vulnerable to the effects of aging (e.g., West & Covell, 2001; Tisserand & Jolles, 2003) and implies that functions supported by the frontal lobes will be disproportionately impaired. This hypothesis is based on age-related alterations in the volume of the frontal cortex (Tisserand et al., 2002) and pronounced age-related decreases in 5-HT2 and D2 receptor availability in the frontal lobes (Wang et al., 1995). Impairments of executive functions such as working memory, inhibition, and planning have consistently been reported (e.g., Brennan et al., 1997; Milham et al., 2002; Thompson-Schill et al., 2002, Treitz et al., in press). Recent cognitive studies have suggested that executive tasks are typically impaired in normal aging, whereas social decision-making tasks are less commonly affected (MacPherson et al., 2002). The authors interpreted their findings in terms of greater impairment in functions supported by dorsolateral prefrontal cortex, with preservation of functions supported by ventromedial prefrontal cortex.

In an early study by Schaier and Cicirelli (1976) three age groups were compared. It was observed that comprehension of jokes decreased with age whereas appreciation increased. Shammi and Stuss (2003) compared older and younger groups, and reported that the older group showed impairment in a joke completion task that required the selecting of correct, funny punchlines from a set of alternatives. The commonest error of the older group included the straightforward and slapstick endings. In addition, performance correlated significantly with measures of executive functions. The authors concluded that comprehension of the cognitive component of humor, which is probably mediated by the dorsolateral cortex, may deteriorate with aging. On a separate task, participants were instructed to rate the funniness of short neutral and humorous verbal statements. The age groups did not differ significantly with respect to the difference score between humorous and neutral items. The authors interpreted the latter findings as evidence of intact (affective) humor appreciation with aging, and suggested that this might be linked to medial frontal structures. The conclusions of Shammi and Stuss (2003) are, however, limited by differences in the complexity of the different tasks used to assess the affective and cognitive components. In addition, it is possible that participants detected that an ending was the correct funny punchline, but still found another ending funnier (e.g., slapstick). Thus the assessment of funniness ratings for each of the different alternatives would be of relevance. Further studies are therefore desirable to shed light on the putative dissociation of the affective and cognitive components of humor in normal aging.

While the role of impaired executive functions in mediating humor processing deficits in normal aging has received some attention, the possible influence of mentalizing (theory of mind) ability has not been investigated. Mentalizing refers to the ability to reason about mental states, including beliefs and intentions, and may be mediated by medial frontal structures (Stuss et al., 2001). One study (Winner et al., 1998) examined the ability of RHD patients to distinguish lies from jokes, and concluded that performance on this task was correlated with the ability to make mental state attributions on a Theory of Mind (ToM) measure. The importance of mentalizing for humor processing was supported by a later study (Happé et al., 1999). Studies of humor processing in autism have also been interpreted in terms of a mentalizing contribution (Happé, 1994). Mentalizing may thus provide a separate route to humor processing, independent of executive skills. Studies investigating mentalizing in normal aging have produced mixed findings, with some suggesting it to be unaffected (e.g., Happé et al., 1998; Saltzman et al., 2000), and others indicating age-related decline (e.g., Maylor et al., 2002; Sullivan & Ruffman, 2004).

The aim of the present study was to investigate the influence of normal aging on cognitive and affective components of humor processing, and to examine the relationships with mentalizing and executive skills. For the assessment of humor processing a similar type of task as in the studies by Brownell et al. (1983) and Shammi and Stuss (1999, 2003) was used with the different alternatives reflecting incongruity and/or resolution. In an extension of previous studies, funniness and logical ratings were obtained for the different alternative punchlines.

METHOD

Research Participants

Eighty-seven healthy participants gave informed consent to take part. The study was completed in accordance with the Helsinki declaration. Participants were given a screening interview and excluded if they had a history of psychiatric or neurological illness, head trauma, or substance abuse. The Mini-Mental State Examination (Folstein et al., 1975) was also administered to exclude participants with possible dementia (cut-off score: 26).

Participants were assigned to three age groups: younger (20–34 yrs; $n = 32$; 12 males, 10 females), middle (40–58 yrs; $n = 29$; 10 males, 19 females), and older (60–78; $n = 26$; 12 males, 14 females). The number of males and females did not differ significantly ($\chi^2 = 0.84$; $p = .67$). The three age groups did not differ significantly in intellectual ability (IQ), assessed by the subtests "Similarities" and "Picture Completion" of the reduced Wechsler Intelligence Scales (WIP; Dahl, 1986) or in mood, assessed by the Beck Depression Inventory (Beck & Steer, 1987). Demographic variables are shown in Table 1.

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Table 1. Demographic data, general intellectual functioning, executive functions, and affect (means and standard errors) in the three age groups

	20–39 years	40–59 years	60+ years
N (ns)	32	29	26
Age**	24.15 (0.73)	49.00 (0.96)	67.46 (1.26)
IQ (ns)	113.41 (1.44)	118.12 (2.05)	118.55 (2.35)
Depression (ns)	3.53 (0.69)	5.79 (1.04)	5.46 (0.74)
Stroop test			
Reading**	26.29 (0.55)	26.64 (0.56)	31.54 (0.96)
Naming*	40.58 (1.46)	39.29 (1.53)	46.38 (1.51)
Interference**	63.28 (1.877)	68.06 (2.62)	92.81 (5.72)
Trail Making Test A**	24.47 (1.30)	31.98 (1.29)	43.43 (2.99)
Trail Making Test B*	64.39 (8.76)	66.60 (3.89)	111.06 (17.58)
Number-letter task (ns)	9.37 (0.35)	8.96 (0.34)	8.53 (0.54)

Note. *$p < .05$; **$p < .0001$; ns indicates that means are not statistically different.

Humor processing and mentalizing

For the assessment of humor processing, a new computerized task was developed, similar to that used in the studies by Brownell et al. (1983) and Shammi and Stuss (1999, 2003), with the different alternatives reflecting incongruity and/or resolution. One hundred and thirty jokes were selected from a large pool, excluding those with potentially offensive themes including religion, politics, illness, or mortality. Each of these jokes was classified by two raters as being dependent on mentalizing ability for the comprehension of the joke. In a second stage, the two original raters and three additional raters assessed the funniness of each joke on a rating scale from 0 ("not funny") to 3 ("very funny"). The raters were aged 47, 30, 25, 26, and 30 years with a mean age of 31.6 ($SD = 8.90$). Twenty-four of the jokes with a funniness rating of > 1 were included in the final test battery.

For each item, the joke stem was initially presented on the screen. In order to minimize memory demands, the joke stem remained on display throughout. After reading the joke stem, participants saw an array of four possible endings, and were instructed to select the correct funny punchline. Four types of endings were used: the correct funny punchline (C), a slapstick ending (S), an illogical ending (I), and a logical ending (L). After the selection of an ending, the joke stem was presented again with each of the alternative endings one after the other. Participants were then asked to rate the funniness ("How funny is this ending? Please rate how funny it makes the story") and logic ("How logical is this ending? Please rate how well it fits to the story?") for each alternative ending on a four-point scale (not funny, slightly funny, fairly funny, very funny and very badly, fairly badly, fairly well, very well). General comprehension was assessed by two simple factual (nonmentalistic) questions. Mentalizing ability was assessed by three mentalistic questions for each joke. During the presentation of the mentalizing questions, the joke including the correct funny punchline was shown on the screen. The first question referred to the perspective of protagonist 1, and the second to the perspective of protagonist 2. The third question referred to the comprehension of the correct, funny punchline. The participants' responses were recorded. The responses to the mentalizing questions were then scored as follows: 2 points for correct answers, 1 point for partially correct answers, 0 points for incorrect answers. All responses were rated by two independent raters, and inter-rater agreement was $> 95\%$ for all questions. Disagreements were judged by a third independent rater. The general comprehension and mentalizing questions were always presented in the same order.

Example of a Joke

Joke stem

"Martin had just started his own company. When a visitor came into the office, Martin picked up the telephone. He pretended to be discussing a multi-million-pound deal. Eventually he put the phone down and said to the visitor: 'Can I help you?' "

Alternative endings

C: "The visitor said: 'Yeah, I've come to connect up your telephone.' "

I: "The visitor said: 'The colour of this wallpaper matches my tie.' "

S: "Martin's chair suddenly collapsed and he fell on the floor."

L: "The visitor said: 'Yes, I'm looking for a job in your new company.' "

Nonmentalistic fact questions

1. "Was the company started by Brad?"
2. "Did Martin work in an office?"

Mentalistic questions

1. "Why did Martin pick up the telephone and speak?"
2. "What did the visitor think when he heard Martin speaking into the telephone?"

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3. "What did Martin think when the visitor said 'Yeah, I've come to connect up your telephone?'"

Measures of Executive Function

Inhibition

Inhibition of a habitual response was measured by the Stroop test (Bäumler, 1985). The participants were told to read aloud color words (printed in black ink) as fast as possible (reading), to name the color of colored lines (naming), and to name the ink color of color words printed in an incongruent color, such as "RED" in green ink (interference). The time taken for each task was recorded.

Set shifting

Psychomotor speed and set shifting were measured by the Trail Making Test (Reitan, 1992). In the first subtest participants drew lines to connect numbers in ascending order. In the second subtest they were asked to alternate between numbers and letters, in ascending order (e.g., 1-A-2-B). Time taken was recorded.

Working memory

Working memory was assessed using a number-letter sequencing test similar to the Letter-Number Sequencing subtest of the Wechsler Memory Scale (Wechsler, 1997). Sequences of letters and numbers were read out by the experimenter (e.g., 2-L-4). Participants were instructed to first repeat the numbers in ascending order followed by the letters in alphabetical order (2-4-L). The number of correctly reproduced sequences was recorded.

RESULTS

Humor processing

Selection of endings from alternatives

Analyses of variance (ANOVAs) with *post hoc* Tukey tests showed significant group differences for the number of correct [$F(2,84) = 14.79$, $p < .0001$], slapstick [$F(2,84) = 3.05$; $p = .05$], and logical choices [$F(2,84) = 17.25$; $p < .0001$]. The older group selected fewer correct punchlines when compared to the other two groups (both $p < .0001$). This is illustrated in Figure 1. They selected a higher number of logical endings in comparison with the two other age groups (both $p < .0001$) and showed a tendency to select more slapstick endings when compared to the younger group ($p = .07$). Differences were confirmed with nonparametric procedures in light of the floor effects observed in some conditions. The data are summarized in Table 2. The results for the funniness ratings are also shown in Table 2.

Statistical analyses of funniness ratings were restricted to trials on which correct alternatives were selected. ANOVAs yielded significant age effects for the funniness ratings for the correct alternatives [$F(2,84) = 4.75$, $p = .01$], which was due to lower scores for the older group in comparison with the middle group ($p = .008$). All groups rated the correct funny punchline as funnier than the other three alternatives (all $p < .0001$). To obtain a clearer measure of the ability to differentiate between funny and neutral items, difference scores between the funniness ratings of the correct and logical alternatives were also calculated. ANOVA yielded significant differences [$F(2,84) = 5.94$, $p = 004$], which was due to lower scores for the older group in comparison with both other groups (both $p < .02$).

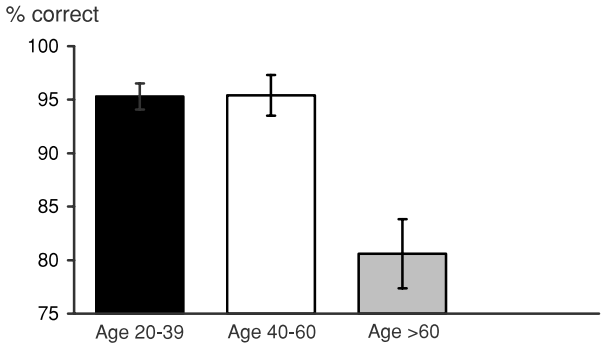

Fig. 1. Results [means and standard error of the means (SEMs) of % correct] of the three age groups in the humor processing task.

The results for the logical ratings are shown in Table 2. Statistical analyses of logical ratings were restricted to trials on which correct alternatives were selected. Analyses yielded significant effects for correct [$F(2,84) = 3.30$, $p = .04$] and logical endings [$F(2,84) = 7.56$, $p = .001$]. Older people rated logical endings as being less logical than both other groups (both $p < .005$). In addition, they showed a tendency to rate correct endings as being less logical than both other groups (both $p < .07$). To obtain a clearer measure of the ability to differentiate between logical and illogical items, difference scores between the logical ratings of the logical and illogical alternatives were also analyzed. ANOVA yielded significant differences [$F(2,84) = 9.82$, $p < 0001$], which were due to lower scores for the older group in comparison with both other groups (both $p < .001$).

The results for the nonmentalistic questions are shown in Table 2. ANOVA showed no significant differences between the three groups in the number of correct nonmentalistic questions [$F(2,84) = 0.80$, $p = .45$).

The responses for the mentalistic questions are illustrated in Figure 2. ANOVA yielded a significant group difference [$F(2,84) = 14.22$, $p < .0001$], which was due to significantly lower scores for the older group in comparison with both other age groups (both $p < .0001$). No other significant results were observed ($p = .67$). Separate analyses for the answers to the first two mentalistic questions (referring to the perspectives of the two protagonists) and the more complex third question (referring to the comprehension of the correct funny punchline) also yielded significant effects (both $p < .002$), which were due to significantly

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Table 2. Percentage of alternative choices for number of correct control questions, funniness, and logical ratings (means and standard errors) in the three age groups

	20–39 years	40–59 years	60+ years
Percent of C choices**	95.31 (1.22)	95.40 (1.91)	80.61 (3.23)
Percent of S choices	1.82 (0.64)	2.01 (1.05)	5.13 (1.41)
Percent of L choices**	1.30 (0.47)	2.44 (1.04)	12.18 (2.38)
Percent of I choices	0.65 (0.32)	0.14 (0.14)	0.96 (0.42)
Nonmentalistic questions (max = 48) (ns)	46.96 (0.53)	47.51 (0.12)	46.88 (0.30)
Funniness ratings (max = 96)			
Correct*	64.25 (2.20)	69.03 (2.49)	58.54 (2.33)
Slapstick	36.97 (2.32)	30.97 (1.59)	32.08 (1.76)
Logical	24.78 (0.41)	27.38 (0.98)	27.62 (1.82)
Illogical	24.38 (0.45)	24.41 (0.61)	23.58 (1.05)
Logical ratings (max = 96)			
Correct	67.25 (2.77)	67.28 (3.02)	58.12 (2.58)
Slapstick	40.47 (1.59)	37.93 (1.72)	37.00 (1.68)
Logical*	67.97 (2.88)	66.93 (3.28)	52.54 (2.96)
Illogical	29.72 (0.95)	29.86 (0.87)	31.08 (1.40)

Note. *$p < .05$; **$p < .0001$; ns indicates that means are not statistically different.

lower scores for the older age group in comparison with the younger groups.

Executive Functions

Inhibition

The performance of the three groups in the Stroop test is shown in Table 1. Repeated-measures ANOVA yielded a significant effect for age group [$F(2,84) = 17.85, p < .0001$], condition [$F(1,84) = 339.56$, $p < .0001$] and a significant group × condition interaction [$F(2,84) = 15.67, p < .0001$], which was due to a significantly larger difference between the conditions "interference" and "naming the color of colored lines" of the older group in comparison with both other groups (both $p < .0001$). ANOVAs of "reading color words," "naming colored lines," and the interference condition showed significant effects [$F(2,84) = 16.90$, $p < .0001$; $F(2,84) = 5.87$, $p = .004$; and $F(2,84) = 19.21$, $p < .0001$), which were due to significantly longer reaction times (RTs) for the older group in comparison with the other age groups (all $p < .02$). In addition, a significant effect emerged for interference corrected for overall response slowing (Interference-naming colored lines/naming colored lines) [$F(2,84) = 10.66$, $p < .0001$], which was due to higher scores for the older group compared to both other groups.

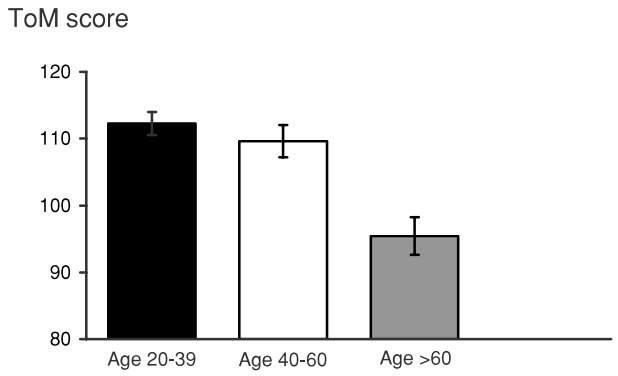

Fig. 2. Results [means and standard error of the means (SEMs)] of the three age groups in the mentalizing task.

Set shifting

The results for the Trail Making Test (TMT) are shown in Table 1. Repeated-measures ANOVA of the TMT (A and B) revealed significant effects of condition [$F(1,84) = 67.40$, $p < .0001$], group [$F(2,84) = 8.20$, $p = .001$], and a tendency for a significant group × condition interaction [$F(2,84) = 2.97$, $p = .06$). This was due to a tendency for a longer difference between both conditions (B-A) for the older group in comparison with the middle group ($p = .06$). Separate ANOVAs for conditions A and B yielded significant age effects [$F(2,84) = 24.52$, $p < .0001$; $F(2,84) = 5.52$, $p = .01$]. Subsequent t tests for condition A and B revealed significantly slower RTs of the older group in comparison with both other groups (all $p < .02$). Analyses for TMT-B performance corrected for overall slowing (TMT-B-TMT-A/TMT-A) did not yield any significant group difference.

Working memory

The results for the number of correctly reproduced numbers and letters are shown in Table 1. No significant group differences were observed ($p = .36$).

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Correlational Analyses

Correlations between humor processing and mentalizing

Pearson correlational analyses including all participants showed that for the humor processing task, mentalizing scores correlated significantly with the number of correct punchlines ($r = .42$, $p < .0001$), funniness ratings for correct punchlines ($r = .44$, $p < .0001$) and difference scores for the funniness ratings (correct-logical) ($r = .50$, $p < .0001$). All correlations were in the expected direction.

Correlations between executive functions and humor processing

When the executive measures were examined, there were significant correlations between the number of correct choices in the humor processing task and two executive measures, the inhibition score (difference between the interference-naming condition) of the Stroop test ($r = -.31$, $p = .004$) and the number of correct sequences in the letter-number sequencing task ($r = .31$, $p = .003$). All significant correlations were in the expected direction. There were no significant correlations between mentalizing scores and the executive measures (all $p > .14$).

Multiple Regression Analyses

Multiple regression analyses with the number of correct punchlines as the dependent variable and age as well as mentalizing as predictors yielded significant effects for age ($p = .002$) and mentalizing ($p = .007$). Three separate regression analyses with the number of correct punchlines as dependent variable and age and each executive measure (set shifting, inhibition, and working memory) as predictors revealed significant effects for age and working memory (both $p < .02$). In addition, multiple regression analyses with the funniness ratings for the correct funny punchline as dependent variable and age, as well as mentalizing, as predictors, showed significant effects for mentalizing ($p < .0001$). Separate regression analyses with the funniness ratings for the correct funny punchline as dependent variable and age and each executive measure (set shifting, inhibition, and working memory) as predictors did not yield any significant effects (all $p > .45$).

DISCUSSION

The present study aimed to assess age effects on humor processing, focusing on both cognitive and affective components of humor. Like the middle and younger groups, older people most commonly chose the correct funny punchline. However, they chose significantly fewer correct punchlines in comparison with both other groups. They made more choices of logical alternatives when compared to both other groups and showed a tendency to select more slapstick endings than the younger group. In addition, older people showed a smaller difference score than both other groups when funniness ratings for the correct funny and logical endings were compared. The logical ratings of older people also differed. They rated the logical alternatives as being less logical when compared to both other groups, and tended to find the correct endings less logical than both other groups. Older people also had a smaller difference score than both other groups when logical ratings for the logical and illogical endings were compared. In addition, older people showed mentalizing deficits as indicated by significantly lower scores on the mentalizing items, and also executive impairments as shown by reduced set shifting and inhibition abilities. As the different age groups of this study did not differ on nonmentalistic fact questions, general intellectual abilities, gender, or affect, such variables cannot explain the observed age differences in humor processing.

The findings of the present investigation imply that older people are impaired with respect to the cognitive component of humor processing. This result is consistent with the investigation by Shammi and Stuss (2003). In the present investigation, the older group also differed from both other groups on the affective component of humor, as reflected by their reduced difference scores for funniness ratings. This may reflect true differences in ability to appreciate the affective aspects of humor, although we cannot rule out the possibility that the results may at least partly be attributable to cohort differences concerning preference for humor types, since the raters who made the initial funniness ratings did not include any from the older age group. The possibility that cohort effects may have influenced the results of the present investigation may also explain why Shammi and Stuss (2003) did not find any effect of age on affective processing. However, their failure to find a difference could also be a function of the task design. In the investigation by Shammi and Stuss (2003) the cognitive and affective components were measured by two different tasks. The two measures may therefore have differed with respect to task complexity, whereas the present design permitted the assessment of both aspects within the same paradigm. In contrast to earlier studies (Brownell et al., 1983; Bihrle et al., 1986; Shammi & Stuss, 1999, 2003) we also assessed the funniness of each of the alternative endings for each joke, because it is possible that participants detected the correct funny punchline for a joke, but still found another ending funnier.

The results of the present investigation can be further interpreted in the context of the imaging study by Goel and Dolan (2001), who discussed different cerebral networks for the cognitive and affective component of humor processing. In addition, Shammi and Stuss (1999) observed impaired humor processing in patients with lesions to the prefrontal cortex. The frontal lobes have been reported to be disproportionately affected during normal aging (West & Covell, 2001; Tisserand & Jolles, 2003). Although the conclusions about brain location on the basis of behavioral data alone are limited, the present results may imply that any humor processing deficits in older people may be related to prefrontal dysfunction. The results of the present inves-

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tigation are thus consistent with the "frontal aging hypothesis," which suggests that the prefrontal cortex is disproportionately vulnerable to age effects (West & Covell, 2001; Tisserand & Jolles, 2003; Treitz et al., in press).

According to incongruity resolution theory, humor processing requires the detection of an incongruent element ("incongruity detection"), which is then resolved in the context of the joke ("resolution"). The comprehension of the correct punchline thus requires both stages, whereas slapstick involves incongruity detection only. The logical alternative includes resolution and the illogical component incongruity detection only. In the present investigation, older people chose significantly fewer correct punchlines in comparison with the younger groups and made more logical choices when they were instructed to choose the correct funny punchline. In addition, the older group showed a tendency to select more slapstick endings than the younger group. Interpreted in this context, the findings of the present investigation imply that older people show mild humor processing deficits when stimuli involve both stages of humor processing, although the possibility of cohort differences in humor preferences remains, as discussed earlier.

Why do older people show deficits in the processing of incongruity resolution humor? One plausible explanation might relate to the higher executive demands that the correct punchline entails. For the selection of the correct funny punchline, participants have to hold the joke context, the different alternatives, and the instructions in memory. In addition, the possible alternative meanings have to be compared, evaluated, and linked to the joke context. Other executive functions such as shifting between different possible meanings and inhibition of dominant but incorrect interpretations could also be of relevance. In the present investigation, the older group showed deficits in inhibition, and these were detected even after controlling for general response slowing. The observed problems of older people in the humor processing task may thus be secondary to inhibitory impairments. This interpretation is consistent with the observed significant correlation between inhibition and the number of correct punchlines, although it should be mentioned that regression analyses did not yield a significant effect of inhibition.

Older people also showed mentalizing deficits as reflected by their lower scores on the mentalizing questions. The observed mentalizing deficits of older people in the present investigation are inconsistent with the study by Happé et al. (1998), who concluded that such abilities remain intact and may even improve in the course of normal aging. The finding of poorer mentalizing in older participants is, however, in accordance with recent investigations in which the same paradigm as in Happé et al. (1998) was used (Maylor et al., 2002; Sullivan & Ruffman, 2004).

Although the influence of mentalizing on humor processing is as yet unclear, several lines of evidence suggest that the ability to represent mental states could be relevant. Winner et al. (1998) reported that the ability to distinguish lies from jokes correlated with mentalizing measures. The potential influence of mentalizing on humor processing is also supported by investigations of humor processing in autism and schizophrenia (Corcoran et al., 1997; Happé, 1994). In the present investigation regression analyses yielded a significant effect of mentalizing ability. This finding is consistent with the interpretation that the humor processing deficits of older people could be at least partly due to mentalizing impairments. This is likely to be of relevance, since for the comprehension of the correct funny punchlines, the recipient is thought to take the perspectives of the characters and appreciate the feeling of superiority associated with disparagement.

The present findings may thus need to be incorporated in the interpretation of results from previous lesion and imaging studies. Since the correct funny punchlines typically employed in previous lesion studies (Brownell et al., 1983; Bihrle et al., 1986; Shammi & Stuss, 1999) at least partly relied on the ability to represent mental states, mentalizing deficits may contribute to the observed impairment pattern in patients with brain damage. Humor processing probably involves distinct networks for the cognitive and affective component of humor. Whereas the cognitive component is mediated by the dorsolateral prefrontal cortex, the affective aspects of humor probably depend on medial and orbital regions. Mentalizing abilities are processed in a network including the medial prefrontal and temporal cortex (Castelli et al., 2000; Gallagher et al., 2000; Stuss et al., 2001; Stuss & Levine, 2002; Gallagher & Frith, 2003). The fact that in the present investigation mentalizing was related to the funniness ratings of the correct punchline, as well as to the number of correct funny punchlines, whereas executive function was related to number of correct endings only, suggests that mentalizing abilities contribute to both the affective as well as the cognitive component, whereas working memory contributes to the cognitive component of humor processing only.

One limitation of the study is ceiling effects for the younger and middle age groups on the humor processing task. Thus, future studies including the manipulation of task complexity would be desirable. It would also be prudent to assess mentalizsing, logical, and funniness ratings both within the same task paradigm, and in separate tasks.

In summary, the present study found that older people showed deficits in humor processing, which appeared to be related to social cognition. Future studies are desirable to investigate the influence of mentalizing on humor processing and the potential implications for incongruity resolution theory in more detail.

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