The influence of empathizing and systemizing on humor processing: Theory of Mind and humor

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Abstract

This paper investigates the influence of empathizing and systemizing on cognitive and affective humor processing in two studies. Three cartoon types differing in their logical mechanisms (LMs) and cognitive requirements were presented to participants with high scores on one scale and low scores on the other (empathizers and systemizers): visual puns, semantic cartoons and Theory of Mind cartoons. Empathizers and systemizers were expected to process these cartoon types differently. While empathizers and systemizers did not differ in recognition time and comprehensibility in study one (N = 33), empathizers did portray higher funniness scores in study two (N = 55). Furthermore, empathizers more often gave emotional|motivational explanations as well as more mentalistic explanations as to why they think a cartoon is funny. In addition, Theory of Mind cartoons provoked the highest number of mentalistic explanations. This shows that stimulus characteristics (such as LMs) as well as inter-individual differences influence whether mentalizing is required and applied to processing humor, and that empathizing and systemizing influence humor appreciation.

Keywords: cartoons, empathizing, humor, logical mechanisms, systemizing, Theory of Mind.

1. Introduction

Cognitive and affective humor responses have been shown to be influenced by individual characteristics such as metalinguistic skills, social competences (see Emerich et al. 2003) or personality (e.g., Ruch 1992; Ruch and Hehl 1998).

Humor 25–1 (2012), 75–98
DOI 10.1515/humor-2012-0005

0933–1719/12/0025–0075

Some models of humor explicitly claim that Theory of Mind, the ability to represent other people's mental states, such as beliefs, desires, emotions and goals in order to predict their actions (Baron-Cohen et al. 1985; Premack and Woodruff 1978), is necessary to process humor (Howe 2002; Jung 2003). Theory of Mind, also called *mentalizing*, has been described as the cognitive component of empathy (e.g., Baron-Cohen 2003).

Several studies that investigated Theory of Mind and humor have arrived at mixed results. Some studies support the so-called mind-reading hypothesis by Howe (2002): For example, normally aged individuals and alcoholic patients show mentalizing deficits that affect the ability to comprehend humor (Uekermann et al. 2006, 2007). Studies on individuals with Autism Spectrum Disorders (ASD), known to have affected mind-reading abilities, present evidence that their humor processing is impaired. They less often recognize when something is intended to be funny (Baron-Cohen 1997) and their comprehension of humorous materials is poorer in that they more often choose a non-funny ending out of several possible endings for a joke setup (Ozonoff and Miller 1996; Emerich et al. 2003).

However, other studies do not support a close relationship between Theory of Mind and humor. Humor appreciation can be impaired even if Theory of Mind abilities are preserved in patients with frontal lobe epilepsy (Farrant et al. 2005). Another study showed that empathy had no influence on processing of neither friendly humor (wit) nor hostile humor (witticism). However, perspective taking (cognitive empathy) was positively correlated to wit and negatively correlated to witticism (Gessner and Kashdan 2006). Forsyth et al. (1997) only partially support the mind reading hypothesis. They found that emotional empathy was negatively correlated with humorousness of jokes with negative ethnic stereotypes, but they found no correlation between empathy and jokes with other negative stereotypes. Moreover, a case report study by Werth et al. (2001) supports the view of a dissociation of humor and Theory of Mind abilities. An autistic person showed the ability to understand, produce and share humor with other people, despite limited mind-reading skills. It is assumed that some individuals with ASD who have highly developed linguistic and cognitive abilities approach humor from a more cognitive/intellectual perspective and are able to grasp the cognitive basis of humor (for a review, see Lyons and Fitzgerald 2004). However, in individuals with ASD, other reasons such as a weak central coherence or less cognitive flexibility (e.g., Frith and Happé 1994), might influence humor processing as well. This literary overview shows that the relation of Theory of Mind abilities, empathy and humor processing is not yet clear.

Theory of Mind or mentalizing has been described as the cognitive component of empathy or empathizing. Apart from systemizing, empathizing is one of two relatively independent psychological dimensions or cognitive styles (Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004), defined as the drive to read emotions and thoughts in others and to respond to these with an appropriate emotion. Systemizing describes the particular interest in systems (encompassing many different systems, such as mechanical, abstract, mathematical, organizational, taxonomical, etc.), and is related to the ability to predict and control the behavior of these systems. Empathizing is used to make sense of an agent's behavior (e.g., individuals), whereas systemizing is mostly used to predict the behavior of non-agentive events or objects (e.g., things, see also Wakabayashi et al. 2006). These two psychological dimensions can be measured by means of the empathy quotient (EQ) and the systemizing quotient (SQ) (Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004).

The Empathizing–Systemizing (E-S) theory postulates that individuals differ on empathizing and systemizing which are organized in a two-dimensional plane. Baron-Cohen et al. (2003) used the term "brain types" to circumscribe three basic cognitive types which describe extreme and balanced constellations of empathizing and systemizing. Individuals scoring high on the EQ and low on the SQ belong to the Type E (the Empathizing brain type: E > S). Type S individuals have low EQ and high SQ scores (the Systemizing brain type: S > E). Type B ("balanced") individuals score similar on both questionnaires (the Balanced brain type: E = S, see also Wakabayashi et al. 2006). For example, more men belong to the Type S group, whereas more women belong to the Type E group (e.g., Goldenfeld et al. 2005). With respect to these dimensions, the present study focuses on the influence of empathizing, which is strongly related to mentalizing, and systemizing on humor processing. Systemizing has not yet been investigated in relation to humor.

However, individual differences are not the only influence on humor processing. Stimulus characteristics, such as the resolvability of the incongruity (e.g., Ruch 1981, 1992; Ruch and Hehl 1998) or Logical Mechanisms (LM) can also influence humor processing. According to the General Theory of Verbal Humor (GTVH, Attardo and Raskin 1991), LMs describe the cognitive rule by which the incongruity of a humorous stimulus (jokes, cartoons, etc.) has to be resolved. Attardo et al. (2002) claim that different LMs exist, such as mirrored roles (two scripts invoking similar roles being juxtaposed so that they mirror each other), juxtaposition (two scripts are presented simultaneously in the same situation), or exaggeration (an element of a script is rendered unusually salient by exaggerating its size or other characteristics). Samson et al.

(2008) used functional Magnetic Resonance Imaging (fMRI) to show that different LMs evoke different networks in the brain. Their results support the view that different LMs require different cognitive abilities, although there is not much difference in behavioral data such as recognition time or funniness ratings. To process a certain group of LMs, Theory of Mind abilities were required as these humorous stimuli can only be understood when an individual can attribute false mental states to the characters portrayed (e.g., the perceiver has to understand that one character does not know what the other character thinks or intends to do). Some studies using fMRI showed that Theory of Mind (TOM) cartoons are processed differently from non-TOM cartoons (e.g., Gallagher et al. 2000; Marjoram et al. 2004; Samson et al. 2008).

In the present paper it shall be investigated whether the processing of cartoons that differ in LMs is influenced by empathizing and systemizing abilities. Three types of non-verbal cartoons will be presented that differ in their LM and are expected to require more or less mentalizing abilities to be processed. Visual Puns (PUN) are based on visual resemblance and do not require mentalizing or empathizing abilities to be understood. Semantic cartoons (SEM) are based on purely semantic (not visual) relationships and can be understood by using either empathizing or systemizing. The punch line of TOM cartoons can only be understood adequately if the participant attributes false mental states to the characters portrayed. It is expected that mentalizing or mind-reading abilities are required to process and appreciate particularly TOM cartoons (see Figure 1).

It is assumed that empathizers and systemizers (with extreme high values on one, but low values on the other scale — this corresponds to the brain types E and S) perform differently when having to process these three groups of cartoons. However, not only rating scales but also explanations as to why the participants think a cartoon is funny have to be taken into account as these explanations might be a more accurate indicator of cognitive processes than simple comprehensibility ratings (see also Loizou 2006; McGhee 1971). It is possible that when only considering data from rating scales, there might be no differences between empathizers and systemizers as they may well focus on different aspects of the cartoons but still arrive at similar funniness ratings (e.g., systemizers may focus more on (il)logical aspects than on social aspects). Following the theoretical assumptions by scholars such as Howe (2002) or Jung (2003), systemizers might have greater difficulty in understanding and appreciating humor independently of the LM. In particular, systemizers should have the greatest difficulty with TOM cartoons. In the two studies presented here, differences in humor processing are expected particularly on the explana-

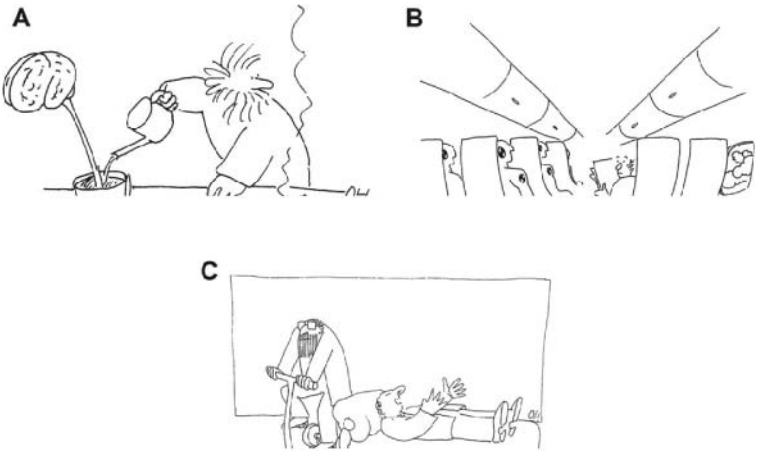

Figure 1. *Examples of cartoons used in the study. (A) Visual puns (PUN) play on the visual similarity of two objects — here a flower on a stem to a brain and its spinal cord. (B) The jokes in semantic cartoons (SEM) are based on semantic relations and not on visual resemblance, as in PUNs: Here, a person finds himself in an airplane with crash test dummies. It is not necessary to take (false) mental states into account to understand the joke. (C) In Theory of Mind (TOM) cartoons it is necessary to infer about other people's (false) mental states, i.e., to understand that the patient is not aware of the therapists' activities but thinks the therapist is attentively listening to his problems. Cartoons: Copyright by Oswald Huber. Permission to use was granted. Cartoon A) is reprinted from "Cartoons: Drawn Jokes?," by C. F. Hempelmann and A. C. Samson, 2008, In: V. Raskin (Ed.). The Primer of Humor Research (pp. 609–640). Berlin: Mouton de Gruyter. p. 616. Copyright 2008 by Oswald Huber. Reprinted with permission. Cartoon B and C) is reprinted from "Perception of other people's mental states affects humor in social anxiety," by A. C. Samson et al. 2012, Journal of Behavior Therapy and Experimental Psychiatry, 43, 625–631. Copyright 2012 by Oswald Huber. Reprinted with permission.*

tion level. Three aspects were coded: whether the participants explained the punch line correctly (according to a GTVH-based expert analysis, Attardo and Raskin 1991), whether the participants refer to emotions or mental states of the characters portrayed in the cartoon, and whether they explicitly refer to false mental states, i.e., Theory of Mind or mentalistic explanations. Empathizers are expected to refer more often to the characters' emotions, motivations and intentions and to more often give mentalistic explanations (e.g., stating that one character does not know what the other character thinks or intends to do).

2. Study 1

2.1. *Method*

2.1.1. *Participants.* In order to find empathizers and systemizers, as many participants as possible were recruited via e-mail, mail, personal communication, notices around the University, etc., to fill in the EQ and SQ in a paper and pencil version. Participants were instructed to judge how strongly they agreed or disagreed with each item. The participants were asked to provide contact information (email, phone number) in case they were interested in participating in a further study. Individuals with extreme scores were invited to participate in the main experiment. One hundred eighty-two participants replied to all items (113 students and 71 non-students; 117 females and 65 males; mean age 29.56 years, $SD = 12.19$). The EQ and the SQ did not correlate significantly ($r = -.06$). As seen in previous studies, females scored higher than males on the EQ ($F(1, 181) = 6.14$, $p < .05$) and lower than males on the SQ ($F(1, 181) = 39.40$, $p < .001$; see table 1).

Table 1. *Means and standard deviations on the EQ and SQ of all participants that filled in the questionnaire and those who were selected and participated in the main experiment in study 1*

		EQ *M (SD)*	SQ *M (SD)*
Whole sample	Males (N = 65)	13.03 (5.23)	14.06 (4.77)
	Females (N = 117)	14.73 (3.91)	9.25 (5.06)
	Total (N = 182)	14.17 (4.43)	10.97 (5.46)
Selected participants	Empathizers (N = 17)	18.06 (3.90)	4.53 (3.30)
	Systemizers (N = 16)	7.00 (3.16)	18.50 (4.10)
	Total (N = 33)	12.70 (6.62)	11.30 (7.97)

In order to select empathizers (brain type: E > S) and systemizers (brain type: S > E), those individuals who had an EQ above one standard deviation and a SQ below one standard deviation were counted as empathizers, while those who had a SQ above one standard deviation and an EQ below one standard deviation were counted as systemizers. With these strong criteria there were not enough participants for the main experiment. Ultimately the participants who had only one value above/below one standard deviation and the other value half of one SD above/below the average were selected.

Thirty-nine individuals were found to fit the criteria of empathizers or systemizers, but only 33 were available to participate in the main experiment (mean age = 28.36, $SD = 10.15$ years). All of them were native German speak-

ers. Seventeen participants (15 female, two male) with high EQ and low SQ scores were categorized as empathizers. Sixteen participants (15 male, one female) with high SQ and low EQ scores were categorized as systemizers (see table 1). One-way ANOVAs yielded significant differences in the EQ ($F(1, 32) = 79.53$, $p < .001$) and SQ ($F(1, 32) = 117.00$, $p < .001$) between these two groups.

2.1.2. *Empathizing and systemizing scales.* The EQ and SQ are two scales that measure differences in empathizing and systemizing (Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004). Here, short German versions were used (Samson and Huber 2010) consisting of 13 EQ items (e.g., "I can easily tell if someone else is interested in or bored with what I am saying.") and 13 SQ items (e.g., "I do not enjoy games that involve a high degree of strategy;" reversely scored). In order to prevent response tendencies the items were presented in a mixed questionnaire, which consisted of 37 items in total: 13 EQ, 13 SQ and 11 filler items. The EQ and SQ have a forced-choice format and are self-administered. As in the original versions, the agreement towards an item can be given on a 4 point scale from "strongly disagree" to "strongly agree". Mild agreement was counted as one point while strong agreement was counted as two points (see also Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004).

2.1.3. *Stimuli.* Three non-verbal types of cartoons with different LMs were investigated: visual puns (PUN), semantic cartoons (SEM) and Theory of Mind cartoons (TOM) (see Figure 1).

PUNs are analogous to verbal or phonological puns, as defined by Hempelmann (2004). In PUNs, the punch line is based on the fact that one visual element activates two scripts that are incongruent with each other. The joke is understood if the person detects and integrates the two scripts (see also Hempelmann and Samson 2007).

SEM cartoons are based on purely semantic relationships in contrast to visual resemblance as in PUNs. Several LMs are subsumed in this stimulus group (e.g., exaggeration, juxtaposition, role exchange, see Attardo et al. 2002).

The third stimulus group, TOM cartoons, is characterized by the fact that mentalizing abilities have to be activated to understand the joke correctly. These cartoons are similar to false belief tasks in the sense that the perceiver has to attribute mental states to the portrayed characters: It has to be recognized that one character does not know what the other character thinks or intends to do.

The stimuli were selected and pre-tested by Samson et al. (2008). In order to reduce the length of the experiment and to constrain the associated work load and humor fatigue effect (i.e., a decrease in the funniness response with increasing number of stimuli, see Forabosco 1994), only 60 of the 90 cartoons used in the previous study were selected randomly (20 per condition). For the explanations of the punch lines, five cartoons were randomly selected per each condition. All participants had to explain the same 15 cartoons.

2.1.4. *Design and procedure.* The independent variable *stimulus conditions*, i.e., the types of cartoons that differed regarding their LM, was varied within subjects and categorization of the participants into empathizers and systemizers is an organismic variable that varied between subjects. The dependent variables were recognition time, comprehensibility and funniness ratings as well as the explanations given by the participants for why they think the cartoon is funny.

Participants were tested individually. After instruction on the procedure, 60 non-verbal cartoons (20 PUNs, 20 SEM and 20 TOM cartoons) were presented randomly on a computer screen. The participants were instructed to press a button as soon as they were sure that they did or did not understand the cartoon to record recognition time. They then had to indicate whether they understood the cartoon or not by pressing one of two buttons (this procedure allowed the exclusion of non-understood cartoons from further analysis). Subsequently, the participants rated the perceived funniness on a seven-point-scale. After having rated all cartoons participants were asked to verbally explain the punch line of each of the 15 cartoons (five per condition) which were presented randomly on single paper sheets. The explanations were recorded by the experimenter.

2.2. *Results*

In the results section, the coding procedure of the explanations and its reliability will be reported first. Then the ratings and codings of the explanations will be analyzed.

2.2.1. *Coding system.* The explanations were coded binomially (yes/no) along the following criteria: The *correctness of the explanation* follows the descriptions of the LMs by Attardo et al. (2002) for the SEM and TOM cartoons and by Hempelmann and Samson (2007) for the PUN condition. A correct explanation of a punch line in the PUN condition always refers to the

visual ambiguity — the participant has to mention, for example, that one visual element evokes two meanings (e.g., ". . . the line represents two things simultaneously: waves and furrows . . ."). In the SEM condition, the specific LM has to be mentioned, for example that the cartoon is based on role exchange (e.g., ". . . the man and the dog changed roles . . ."). In order to get a correct score in the TOM cartoon condition, the specific LM for the TOM cartoon has to be mentioned (e.g., ". . . person X does not know what person Y is doing behind his back . . ."), that is, the participant has to refer to the false belief of a character portrayed in the cartoon.

Since it might be possible to give a wrong mentalistic explanation or even give a mentalistic explanation for a PUN or SEM cartoon, it was coded independently of a correct explanation whether participants gave a *mentalistic explanation*.

Furthermore, it was coded (again independent of correctness) whether the participant gave an *emotional/motivational explanation* (e.g., ". . . the dog feels good in the position of the man, whereas the man feels bad in the position of the dog . . ." or ". . . the man *desires* to do xy . . .") in contrast to an explanation without emotion or motivation (e.g., ". . . this is based on role exchange . . ." or ". . . the man does xy . . .").

A random sample of 120 explanations per coding (correct explanations, motivational/emotional explanations and mentalistic explanations; in total 360 codings, which are 24.24% of the in total 1485 codings) was coded additionally by a second rater in order to test the reliability of the coding procedure. Interrater reliability was satisfactorily high for *correct explanations* in general ($\kappa = .83$), as well as for PUNs ($\kappa = .93$), SEM ($\kappa = .76$) and for TOM cartoons ($\kappa = .80$); for *emotional/motivational explanations* in general ($\kappa = .94$), as well as for PUN ($\kappa = 1.00$), SEM ($\kappa = .93$), and TOM cartoons ($\kappa = .90$); for *mentalistic explanations* in general ($\kappa = .83$), as well as for PUN (there was 100% agreement), SEM ($\kappa = .79$) and for TOM cartoons ($\kappa = .79$) — usually, a Kappa (κ) of .70 is considered as very satisfactory. Neither of the coders knew whether the participants were systemizers or empathizers.

2.2.2. *Humor ratings.* Comprehensibility, recognition time and funniness ratings were analyzed by means of repeated measures analyses of variances (rmANOVAs) with the three stimulus conditions as within-subjects factor and empathizers vs. systemizers as between-subjects factor, followed by Bonferroni-adjusted single comparisons. One-way ANOVAs were computed in order to analyze differences between empathizers and systemizers independent of the cartoon types. Table 2 reports means and standard deviations and

Table 2. *Means, standard deviations and Cronbach α's of recognition time, comprehensibility and funniness ratings for all PUNs, SEM, and TOM cartoons (20 per condition) in the two groups (empathizers and systemizers) in study 1 (N = 33)*

		Empathizers	Systemizers	Cronbach α
Recognition time	PUN	6.55 (4.21)	6.89 (2.92)	.93
(in seconds)[1]	SEM	6.26 (3.51)	6.92 (3.13)	.93
M (SD)	TOM	6.93 (3.69)	7.62 (2.92)	.92
Comprehensibility	PUN	0.89 (.14)	0.90 (.15)	.81
M (SD)	SEM	0.92 (.09)	0.92 (.10)	.66
	TOM	0.91 (.10)	0.94 (.09)	.73
Funniness	PUN	2.43 (.98)	2.67 (.94)	.91
M (SD)	SEM	2.46 (.95)	3.05 (.94)	.90
	TOM	2.59 (.94)	3.06 (.87)	.89

Notes. [1] For all dependent variables, 3 × 2 rmANOVAs were computed with stimulus conditions as within-subject variable and the groups (empathizers vs. systemizers) as between-subject variable. Furthermore, a one-way ANOVA was computed for the groups independently of the stimulus conditions. Only recognition time revealed a significant effect for the stimulus conditions (*Mauchly's W* = .73, $\chi^2(2) = 9.28$, $p < .05$; Greenhouse Geisser: $F(1.58, 48.97) = 8.93$, $p < .001$).

Cronbach α's of the humor ratings, as well as the statistical analyses. The Cronbach α's show that the independent variables are stable constructs with respect to the dependent variables.

Recognition time: After excluding the non-understood cartoons, a rmANOVA showed a significant main effect for the cartoon condition. SEM cartoons were processed faster than TOM cartoons ($t(32) = 2.91$, $p < .05$) and PUNs were processed faster than TOM cartoons ($t(32) = 3.59$, $p < .01$). The interaction between stimulus condition by group as well as the one-way ANOVA over all conditions was not significant.

Repeated measures ANOVAs, as well as one-way ANOVAS over all three stimulus conditions, revealed no significant effects regarding the *comprehensibility response* and *funniness ratings.* The lack of differences in the comprehensibility response might be due to the fact that most of the cartoons were understood (on average, 91.15% of the cartoons).

2.2.3. *Humor explanations.* For each participant, the sums of correct explanations, emotional/motivational and mentalistic explanations were computed for the three stimulus conditions independent of subjective comprehensibility. Repeated measures ANOVAs were computed with the three stimulus conditions as the repeated factors and empathizers vs. systemizers as the between-subjects factor, followed by Bonferroni-adjusted single comparisons and one-way ANOVAS for the difference between the two groups (see table 3 for means, *SD* and statistics).

Table 3. *Means and standard deviations for the correctness of the explanation, whether an emotional/motivational or a mentalistic explanation was given for the 5 cartoons of each stimulus condition (PUNs, SEM, and TOM cartoons) in the two groups (empathizers and systemizers) in study 1 (N = 33)*

		Empathizers	Systemizers
Correctness[1]	PUN	4.00 (1.00)	3.94 (1.12)
	SEM	3.76 (1.25)	3.75 (1.18)
	TOM	2.59 (1.33)	1.75 (1.29)
Emotional/motivational explanation[2]	PUN	.82 (1.13)	.06 (.25)
	SEM	.82 (.85)	.81 (.75)
	TOM	2.00 (1.37)	1.44 (1.09)
Mentalistic explanation[3]	PUN	.06 (.24)	.06 (.25)
	SEM	.53 (.51)	.38 (.62)
	TOM	3.18 (1.07)	1.81 (1.22)

Notes. [1] For all dependent variables, 3 × 2 rmANOVAs were computed with stimulus conditions as within-subject variable and the groups (empathizers vs. systemizers) as between-subject variable. Furthermore, a one-way ANOVA was computed for the groups independently of the stimulus conditions. For the *correctness of the explanations*, a rmANOVA yielded a significant effect for the stimulus conditions ($F(2, 62) = 18.64$, $p < .001$).
[2] A rmANOVA yielded a significant effect for the stimulus conditions ($F(2, 62) = 18.64$, $p < .001$).
[3] A rmANOVA yielded a significant effect for the stimulus conditions (*Mauchly's* $W = .56$, $\chi^2(2) = 17.38$, $p < .001$; Greenhouse Geisser: $F(1.39, 43.07) = 102.43$, $p < .001$) and a significant interaction for stimulus conditions by group ($F(1.39, 43.07) = 8.39$, $p < .001$). A one-way ANOVA yielded a significant difference between empathizers and systemizers ($F(1,32) = 11.62$, $p < .001$).

Correctness of the explanation: A rmANOVA yielded that the three stimulus conditions differed significantly. More correct answers were given for PUNs in comparison to TOM cartoons ($t(32) = 7.07$, $p < .001$), as well as for SEM in comparison to TOM cartoons ($t(32) = 6.72$, $p < .001$). The interaction as well as the one-way ANOVA was not significant.

Following this, the subjective comprehensibility ratings and the correct explanations of the 15 cartoons were compared. It is remarkable that the sums of the correct explanations (mean sum = 9.91, $SD = 2.83$) were slightly lower than the subjective comprehensibility responses (mean sum = 13.55, $SD = 1.92$); this can be explained by the fact that in some cases participants indicated that they subjectively understood the cartoon but gave an incorrect explanation of the LM.

Correlations were computed for the mean subjective comprehensibility response (whether the participants indicated that they had understood the cartoon or not) of the five PUNs, SEM and TOM cartoons that had to be explained and the mean correctness of the explanations (whether they referred to the correct LM in their explanation). The correlation within the PUNs ($r = .67$, $p < .001$)

and within the SEM cartoons ($r = .40$, $p < .05$) was positive. Interestingly, there was no significant correlation for the correctness of the explanation and the comprehensibility response in TOM cartoons ($r = .29$, $p = .10$). This means that the participants gave explanations that sometimes had nothing to do with the real LM. Therefore people found some aspect of the cartoon funny, but not necessarily the correct LM.

Emotional/motivational explanations: A rmANOVA revealed a significant main effect for the stimulus conditions. The participants referred to emotional or motivational states significantly more often in TOM cartoons than in PUNs ($t(32) = 6.06$, $p < .001$) and more often in TOM than in SEM cartoons ($t(32) = 3.73$, $p < .01$). Although the interaction was not significant, empathizers were compared to systemizers in order to identify tendencies in the response patterns: Empathizers referred significantly more often to emotional or motivational states in PUNs ($F(1, 32) = 6.91$, $p < .05$).

Mentalistic explanations: A rmANOVA showed a significant main effect for the stimulus condition. Single comparisons yielded significant differences for PUN vs. SEM ($t(32) = 3.71$, $p < .01$), SEM vs. TOM ($t(32) = 8.65$, $p < .001$) and PUN vs. TOM cartoons ($t(32) = 10.46$, $p < .001$). The interaction was significant. Empathizers gave significantly more mentalistic explanations in the TOM condition than systemizers ($F(1, 32) = 11.62$, $p < .01$). Independent of the stimulus conditions, empathizers and systemizers did not differ.

Funniness and correctness of the explanation: Although not in the scope of the main questions of this paper, the effect of the correctness of the explanation on the perceived funniness was also analyzed by comparing the mean funniness ratings of correctly explained cartoons to the mean funniness ratings of incorrectly explained cartoons. As only a part of the participants had both correctly and incorrectly explained cartoons for each of the three cartoon types, three separate paired sample t-tests were computed (had an ANOVA been administered most participants would have had to be excluded due to missing data). The comparison of the funniness ratings of the PUNs that were explained correctly ($M = 2.16$, $SD = 1.34$) with the funniness ratings of the PUNs that were not explained correctly ($M = 2.01$, $SD = 1.33$) showed no significant effect ($t(19) = .40$, $p = .69$). It has to be mentioned that only participants who gave at least one wrong and at least one correct explanation were included in the analysis ($N = 20$).

Correctly explained SEM cartoons ($M = 3.00$, $SD = 1.12$) were perceived to be funnier than incorrectly explained SEM cartoons ($M = 1.65$, $SD = 1.54$) ($t(21) = 3.96$, $p < .001$), whereas correctly explained TOM cartoons ($M = 3.19$, $SD = 1.17$) were not perceived to be funnier than incorrectly explained TOM

cartoons ($M = 2.79$, $SD = 1.37$) ($t(27) = 1.61$, $p = .120$). Although there is a tendency that correctly explained cartoons are perceived as funnier, this cannot be confirmed for all three conditions.

3. Discussion

The main results of the first study can be summarized as follows: There were no significant differences in recognition time, comprehensibility and funniness ratings between empathizers and systemizers, but empathizers gave mentalistic explanations in TOM cartoons more often. Furthermore, empathizers tend to give emotional/motivational explanations in PUNs more frequently. This is remarkable because PUNs can actually be explained without taking into account emotional or motivational states — the joke is essentially based on visual ambiguity. However, as the interaction was not significant, it cannot be claimed that this effect is consistent, so it needs to be investigated with a second sample.

Logical Mechanisms (LM) seem to influence humor processing. The three groups of LMs differed on all dependent variables except for subjective comprehensibility and funniness ratings. A previous study showed that social aspects in SEM and particularly TOM cartoons, in contrast to PUNs which are mainly based on visual ambiguities, lead to an increase in the funniness response (Samson et al. 2008). As the present study does not confirm this (although there is a tendency for it) a further study with more participants will investigate this effect. However, it can be shown here, that TOM cartoons provoke significantly more mentalistic explanations than SEM cartoons, and the latter more than PUNs. It might be concluded that not all humorous stimuli require mentalizing to the same degree.

It is striking that the group of empathizers consists of 88% females, whereas the group of systemizers consists of 94% males. However, this is in line with the E-S Theory: Sex differences are found in empathizing (stronger in females) and systemizing (stronger in males). A growing body of evidence suggests that males spontaneously systemize to a greater degree than females, while females spontaneously empathize to a greater degree than males (Baron-Cohen et al. 2003; Lawson et al. 2004). In this study we were not interested in gender differences in humor processing, but in differences in the absolute values on the EQ and SQ. However, some studies have shown that males and females do not show differences in cognitive humor processing (e.g., the preference for incongruity-resolution humor, see Ruch and Hehl 1998, or Lowis 2002). To

clarify the influence of gender on humor explanations, a second study that considers explanations given by empathizers and systemizers will pay attention to the ratio of males and females in the two groups.

Although systemizers did not perform worse than empathizers on the rating scales and the correctness of explanations in this experiment, it might be possible that systemizers have difficulties recognizing when something (an utterance or action) is intended to be funny. This is suggested in a study by Baron-Cohen (1997) that showed that autistic children (normally having higher systemizing and lower empathizing abilities) portray a persistent failure to "get jokes". The participants in the present experiment knew that they had to judge and explain humorous cartoons, therefore this aspect was not tested. This could be taken into account in a further study, for example, by including pictures that resemble cartoons but contain only incongruities that can not be resolved (e.g., Samson et al. 2008). If systemizers really have difficulties recognizing when something is intended to be funny, they might not realize that a non-funny cartoon (i.e., a stimulus without the possibility of being resolved) does not contain resolvable incongruities and therefore is not funny.

4. Study 2

In order to back up the results of the first study, a second sample was investigated with several alterations. First, the aim was to find a group of empathizers and systemizers that does not differ in the distribution of genders. Thus, the selection criteria were different from the first study. The data presented here are part of a study that aimed to investigate humor processing of individuals with Asperger's syndrome in contrast to healthy controls with varying scores on the EQ and SQ (Samson and Hegenloh 2008). Here, only healthy individuals with extreme scores on the EQ and SQ were taken into account. As the data were collected online, several differences exist between the first and second study: As the participants had to explain *each* cartoon in writing, the number of the stimuli had to be reduced in order to reduce the overall length of the experiment. Furthermore, no recognition times were collected as the program did not allow for that. The online study again presented PUNs, SEM and TOM cartoons, as well as an additional control condition which consisted of unfunny pictures containing an irresolvable incongruity (INC). This made it possible to identify whether systemizers are worse in distinguishing between humorous and non-humorous stimuli.

4.1. *Method*

4.1.1. *Participants.* Participants were recruited via mailing lists at Swiss and German universities. In total, 113 healthy participants (mean age 25.37 years, *SD* = 6.21) completed the online experiment. 61% of them were female. The EQ and SQ did not correlate significantly ($r = -.13$, $p = .17$).

The aim was to determine and select empathizers and systemizers according to their median split for males and females separately (see table 4 for means, *SD* and median). Eighteen females and 8 males were identified as empathizers, 11 males and 18 females were identified as systemizers. The proportion of males and females in the empathizers and systemizers groups did not differ significantly ($\chi^2(1) = .31$, $p = .58$). Empathizers and systemizers differed significantly on the EQ ($F(1, 54) = 100.30$, $p < .001$, and on the SQ ($F(1, 54) = 47.16$, $p < .001$).

Table 4. *Means and standard deviations on the EQ and SQ of all participants that filled in the questionnaire and the selected participants (empathizers and systemizers) for the main experiment in study 2*

		EQ *M (SD); median*	SQ *M (SD); median*
Whole sample	females (N = 69)	13.94 (5.27); 14	7.09 (3.91); 7
	males (N = 44)	11.54 (6.20); 13	11.70 (5.25); 10
	total (N = 113)	13.01 (5.57); 14	8.89 (5.00); 9
Empathizers	females (N = 18)	18.22 (3.06)	3.06 (1.80)
	males (N = 8)	17.99 (3.63)	8.25 (2.60)
	total (N = 26)	17.85 (3.22)	4.65 (3.17)
Systemizers	females (N = 18)	8.28 (4.08)	9.67 (2.63)
	males (N = 11)	7.00 (4.22)	14.64 (4.41)
	total (N = 29)	7.79 (4.10)	11.55 (4.14)

4.1.2. *Stimuli.* The same conditions (PUN, SEM and TOM cartoons) as in study 1 were investigated. In order to avoid humor fatigue effects (Forabosco, 1994) and because for *each* cartoon an explanation had to be given, only eight stimuli per cartoon condition were presented. Additionally, four pictures containing an irresolvable incongruity served as a control condition (INC). These cartoon-like pictures are perceived to be non-funny and have high residual incongruity (see Samson et al. 2008).

4.1.3. *Design and procedure.* In the mailing lists people were invited to participate in an online humor experiment. In the beginning of the experiment,

they received instructions to rate each cartoon for comprehensibility (yes/no), for funniness (on a 6 point scale from 0 to 5) and to explain in writing why they thought a cartoon was funny as well as to explain the punch line. Before the humor experiment started, participants were asked to fill in the EQ and SQ (as in study 1) online. In total, 29 stimuli (24 funny cartoons, four control stimuli and one warm-up) were presented in random order.

4.2. *Results*

After the description of interrater reliability, 4 × 2 rmANOVAs for the humor ratings with the four stimulus conditions as within-subjects factor and empathizers vs. systemizers as between-subjects factor will be reported. For the humor explanations, 3 × 2 rmANOVAs with PUN, SEM and TOM cartoons will be computed. These analyses will be followed by Bonferroni-adjusted single comparisons and one-way ANOVAS to compare empathizers vs. systemizers independent of the stimulus conditions.

4.2.1. *Coding system.* As in the first study, the explanations were coded for the correctness of the explanation, the reference to emotional or motivational states and for mentalistic explanations.

In order to test the reliability of the coding procedure, a random sample of 110 explanations per coding (in total 330 codings, 25% of the 1320 codings) was coded by a second rater. Interrater reliability was satisfactorily high for correct explanations in general ($\kappa = .98$), for PUNs ($\kappa = 1.00$), SEM ($\kappa = .94$) and for TOM cartoons ($\kappa = .99$); for reference to emotional/motivational states in general ($\kappa = .98$), for PUNs ($\kappa = .98$), SEM ($\kappa = .98$) and for TOM cartoons ($\kappa = .97$); for mentalistic explanations in general ($\kappa = .92$), PUN ($\kappa = .73$), SEM ($\kappa = .86$) and TOM cartoons ($\kappa = .94$). Neither of the coders knew whether the participants were systemizers or empathizers.

4.2.2. *Humor ratings.* Table 5 reports means, standard deviations and Cronbach α's of the humor ratings, as well as the general statistics. Computing of Cronbach α's showed that the independent variables are stable constructs except for the INC condition. This is probably due to the number of stimuli in the control condition (four).

Comprehensibility: The four stimulus conditions differ significantly in their comprehensibility (all $p < .001$): INC vs. PUN: $t(54) = 6.36$; INC vs. SEM: $t(54) = 10.49$; INC vs. TOM: $t(54) = 9.50$; PUN vs. SEM: $t(54) = 4.99$; PUN

Table 5. *Means, standard deviations and Cronbach α's of the comprehensibility and funniness ratings for the INC (4 per condition), PUNs, SEM and TOM cartoons (8 per condition) in the two groups (empathizers and systemizers) in study 2 (N = 55)*

		Empathizers	Systemizers	Cronbach α
Comprehensibility[1]	INC	.39 (23)	.43 (.34)	.34
M (SD)	PUN	.73 (.18)	.67 (.23)	.59
	SEM	.84 (.14)	.80 (.17)	.57
	TOM	.82 (.16)	.82 (.18)	.62
Funniness[2]	INC	1.91 (1.04)	1.67 (.82)	.55
M (SD)	PUN	3.68 (1.00)	2.98 (1.08)	.76
	SEM	4.15 (1.03)	3.27 (.97)	.76
	TOM	4.41 (1.10)	3.57 (.97)	.80

Notes. [1] For all dependent variables, 4 × 2 rmANOVAs were computed with stimulus conditions as within-subject variable and the groups (empathizers vs. systemizers) as between-subject variable. Furthermore, a one-way ANOVA was computed for the groups independently of the stimulus conditions. There was a significant effect of the stimulus conditions (Mauchly's $W = .45$, $\chi^2(5) = 41.30$, $p < .001$; Greenhouse Geisser ($F(1.93, 102.37) = 61.94$, $p < .001$) in *comprehensibility.* [2] Significant effect of stimulus conditions (Mauchly's $W = .64$, $\chi^2(5) = 21.52$, $p < .01$; Greenhouse Geisser ($F(2.38, 116.53) = 122.49$, $p < .001$) on funniness. Furthermore, a one-way ANOVA yielded a significant difference between empathizers and systemizers ($F(1, 49) = 7.95$, $p < .001$).

vs. TOM: $t(54) = 4.74$, except for the comparison SEM vs. TOM cartoons. The interaction was not significant. Furthermore, there was no significant group difference independent of the four stimulus conditions.

In order to investigate if systemizers have difficulties recognizing when something is intended to be funny a difference score was computed between the three cartoon conditions excluding the control condition. A one-way ANONA showed that empathizers and systemizers did not differ in their ability to discriminate between humorous and non-humorous stimuli ($F(1, 54) = .68$, $p = .41$).

Funniness: For the analysis of the funniness response, mean funniness ratings of the subjectively understood cartoons and of the non-understood (in contrast to misunderstood) INCs were computed. The stimulus conditions differed significantly (Mauchly's $W = .64$, $\chi^2(5) = 21.52$, $p < .01$; Greenhouse Geisser ($F(2.38, 116.53) = 122.49$, $p < .001$). All stimulus conditions differed significantly from each other (all $p < .001$: INC vs. PUN: $t(50) = 11.33$; INC vs. SEM: $t(50) = 12.74$; INC vs. TOM: $t(50) = 14.19$; PUN vs. SEM: $t(54) = 5.71$; PUN vs. TOM: $t(54) = 5.71$), except for SEM vs. TOM cartoons. The interaction of stimulus conditions by groups was marginally non-significant ($F(2.38, 116.54) = 2.74$, $p = .059$). However, there was a significant group effect independent of the stimulus conditions. Empathizers had significantly higher funniness scores than systemizers ($F(1, 49) = 7.95$, $p < .01$).

4.2.3. *Humor explanations.* For each participant, the sums of correct explanations, emotional/motivational and mentalistic explanations were averaged for each humorous stimulus condition. The codings were analyzed with 3 × 2 rmANOVAs with the three cartoon conditions as within-subjects variable and empathizers vs. systemizers as between-subject variable, followed by Bonferroni-adjusted single comparisons (see table 6 for statistics).

Table 6. *Means and standard deviations for the correctness of the explanation, whether an emotional/motivational and a mentalistic explanation was given for the 8 cartoons of each stimulus condition (PUNs, SEM, and TOM cartoons) in the two groups (empathizers and systemizers) in study 2 (N = 55)*

		Empathizers	Systemizers
Correctness[1]	PUN	5.38 (2.23)	5.24 (2.05)
	SEM	6.38 (1.77)	6.41 (1.82)
	TOM	5.42 (1.50)	4.93 (1.44)
Emotional/motivational Explanation[2]	PUN	1.54 (1.50)	.72 (1.11)
	SEM	1.85 (1.26)	1.66 (.97)
	TOM	4.00 (1.60)	2.66 (1.56)
Mentalistic explanation[3]	PUN	.35 (.56)	.03 (.19)
	SEM	.42 (.70)	.03 (.19)
	TOM	3.18 (1.07)	2.31 (2.01)

Notes. [1] For all dependent variables, 4 × 2 rmANOVAs were computed with stimulus conditions as within-subject variable and the groups (empathizers vs. systemizers) as between-subject variable. Furthermore, one-way ANOVAs were computed in order to analyze the difference between empathizers and systemizers independently of the stimulus conditions. There was a significant main effect for stimulus conditions ($F(2, 106) = 17.10$, $p < .001$) regarding the correctness of the explanations.

[2] There was significant main effect for stimulus conditions (Mauchly's $W = .85$, $\chi^2(2) = 8.55$, $p < .05$, Greenhouse Geisser: $F(1.74, 92.04) = 61.92$, $p < .001$) regarding the reference to emotional and motivational states, as well as a significant interaction ($F(1.74, 92.04) = 4.03$, $p < .05$). Furthermore, empathizers gave more emotional/motivational explanations ($F(1, 53) = 7.95$, $p < .01$).

[3] There was significant main effect for stimulus conditions (Mauchly's $W = .32$, $\chi^2(2) = 59.46$, $p < .001$; Greenhouse Geisser ($F(1.19, 63.05) = 88.03$, $p < .001$) regarding mentalistic explanations. Furthermore, empathizers gave more mentalistic explanations ($F(1, 53) = 8.91$, $p < .001$).

Correctness of the explanation: A rmANOVA revealed a significant effect for the stimulus conditions ($F(2, 106) = 17.10$, $p < .001$). SEM cartoons provoked more correct explanations than PUNs ($t(54) = 5.32$, $p < .001$) and TOM cartoons ($t(54) = 5.50$, $p < .001$), whereas PUNs and TOM cartoons did not differ from each other. As in the first study, the interaction of stimulus conditions by groups was not significant. There was a no significant group effect independent of the stimulus conditions.

Emotional/motivational explanations: A rmANOVA revealed a significant main effect for the stimulus conditions: In TOM cartoons, the participants referred to emotional or motivational states significantly more often than in PUNs ($t(54) = 9.45$, $p < .001$) and in SEM cartoons ($t(54) = 6.89$, $p < .001$), as well as more often in SEM cartoons as compared to PUNs ($t(54) = 3.86$, $p < .001$). Furthermore, the interaction was significant. Empathizers gave more emotional/motivational explanations independent of the stimulus conditions, as well as in PUNs ($F(1, 54) = 5.34$, $p < .05$) and in TOM cartoons ($F(1, 54) = 24.79$, $p < .01$). Therefore, the tendency for empathizers to refer more often to emotional or motivational states found in the first study was confirmed.

Mentalistic explanations: The stimulus conditions differed significantly from each other: TOM cartoons provoked significantly more mentalistic explanations than PUNs ($t(54) = 9.40$, $p < .001$) and more than SEM cartoons ($t(54) = 9.63$, $p < .001$). The interaction was not significant. However, empathizers gave significantly more mentalistic explanations than systemizers independently of the stimulus conditions.

4.3. *Discussion*

Overall, the replication sample revealed comparable results to study one, as well as some new findings: First, no differences in comprehensibility were found between the two groups of empathizers and systemizers, which is in line with the first study. Second, empathizers show a higher emotional response (i.e., funniness scores) than systemizers, which is in contrast to the first study. A reanalysis of all 113 participants of the second study showed that funniness scores correlated significantly with the difference of empathizing-systemizing scores in all three cartoon conditions (PUNs: $r = .29$, $p < .01$, SEM cartoons: $r = .27$, $p < .01$ and TOM cartoons: $r = .29$, $p < .001$). As this sample was bigger than in the first study, it is very possible that empathizing and systemizing do indeed influence the emotional response towards humorous stimuli. Third, empathizers and systemizers did not significantly differ in the number of correct explanations, as they did in the first study. However, empathizers refer to emotional or motivational states (in PUNs and TOM cartoons) more often, which was assumed on the basis of the first study. Concerning the mentalistic explanations, the results of the first study could be replicated: Empathizers give more mentalistic explanations and, again, TOM cartoons provoked more explanations that refer to false mental states. As it was controlled for gender, the effects found are related to differences in empathizing and systemizing, not gender.

5. General discussion

These are the first studies to investigate the influence of the two cognitive styles empathizing and systemizing (e.g., Baron-Cohen 2003) on cognitive and affective humor processing in non-verbal cartoons with different Logical Mechanisms (LMs) or LM groups (visual puns, semantic cartoons and Theory of Mind cartoons). Differences in brain activation patters associated with the three LM groups have already been shown in a previous study (Samson et al. 2008). The present paper shows LM groups also influence response patterns that can be seen in rating scales, but most importantly in explanations why the participants think a cartoon is funny. The requirement to mentalize to understand the punch line in TOM cartoons leads to longer recognition times, as well as more emotional and mentalistic explanations. Furthermore, TOM and SEM cartoons are perceived to be funnier than PUNs that are based on visual ambiguity. This confirms that social cognition and involvement, such as mentalizing, can be seen as factors that enhance funniness (Samson et al. 2008). Visual puns seem to be more difficult to understand and provoke less emotional/motivational and mentalistic explanations.

However, not only stimulus characteristics influence the humor response. As the second study revealed, systemizers are not less capable to discriminate between potentially funny and unfunny material. Furthermore, empathizers and systemizers do not differ on any of the comprehensibility variables. Therefore, the conclusion can be drawn that empathizers — known to have better Theory of Mind abilities than systemizers — do not understand humor *better*, which would have been predicted by the mind-reading hypothesis (Howe 2002), but they understand it *differently*: For example, it seems to be a characteristic of empathizers — known to have stronger emotional and cognitive empathy — to refer more often to emotional or motivational states even if the joke is abstract (as in visual puns) and even though emotional/motivational states are not the main incongruity or LM of the joke. This is remarkable, because PUNs can actually be explained without emotional or motivational states, since the joke is based on visual ambiguity. Systemizers, on the other hand, tend to give more frequently logical or abstract and less frequently emotional or motivational explanations. These findings are in line with the assumptions of Baron-Cohen's E-S theory (2003), which predicts that empathizers tend to focus on agent's behavior and other people's emotions and thoughts, whereas systemizers tend to focus on the behavior of non-agentive events or objects or non-emotional aspects of agents.

The second study revealed that empathizers show even higher funniness ratings than systemizers. This effect might be due to the stronger emotional responsiveness related to the higher emotional empathy. That emotional responsiveness influences the humor response was already shown by Herzog and Anderson (2000). However, the instrument (empathizing and systemizing scales) used here is not sensitive to different components of empathizing (e.g., more cognitive or more emotional components). Future studies might investigate in more detail the relationship between emotional and cognitive empathy in relation to different LMs. However, it has to be mentioned here that the present study did not investigate the relation between EQ, SQ and other cognitive measures (e.g., verbal IQ, executive function) — again, future studies might address this question.

Interestingly, the affective response was largely independent of the correctness of the explanation (only in SEM cartoons were the funniness ratings higher when the participants referred to the correct LM; see study 1). More important is that the participant has the impression that he or she understood the cartoon. In other words, it is important to resolve an incongruity in any way and to make sense *subjectively*, but it is not important whether the intended LM is recognized. Even if a certain cartoon is based on false beliefs or TOM, it does not necessarily mean that all individuals interpret the exact same cognitive rule. Individuals may sometimes come up with other explanations and other cognitive rules. Ruch (1981) has already shown that participants have sometimes the impression that they understand the punch lines correctly but give totally different explanations. According to Hempelmann and Attardo (2011), a joke or cartoon may consist of several incongruities, but it has a salient one that must be resolved in order to understand the punch line of the joke or cartoon. The other incongruities, called backgrounded incongruities (see Samson and Hempelmann 2011), may or may not additionally influence the perceived funniness. It might be interesting to examine whether participants who refer to the backgrounded incongruities instead of the foregrounded incongruity show lower amusement.

The second study included a control condition in order to investigate participants' discrimination ability between humorous stimuli and stimuli that can not be meaningfully resolved. It nevertheless remains open whether systemizers have more difficulties recognizing that an utterance is intended to be funny in a *social situation*. Whether systemizers understand humor less well in daily life or whether they might have similar difficulties as the ones described for individuals with ASD (e.g., Baron-Cohen 1997) has not yet been investigated.

Therefore, it is conceivable to design an experiment that investigates humor more specifically in a social setting.

Taken together, the studies in this paper show that cognitive as well as affective humor processing is influenced by both stimulus characteristics such as the LM and inter-individual characteristics such as empathizing and systemizing. It depends on stimulus characteristics as well as inter-individual differences whether mentalizing or Theory of Mind is required or applied in humor processing. The view that humor processing *always* requires mentalizing is too simplistic (e.g., Howe 2002). This has the important implication that if future research focuses on Theory of Mind in relationship to humor, it is essential to select or control the stimuli carefully for their LM and the resulting cognitive requirements. Differences in stimulus characteristics might explain why some of the previous studies support a tight relationship between Theory of Mind and humor (e.g., Uekermann et al. 2006) while others do not (e.g., Werth et al. 2001). Furthermore, the present study revealed that it is fruitful to analyze explanations as to why someone thinks a cartoon is funny. It is suggested to include explanations more often in further studies in order to gain deeper understanding of cognitive mechanisms underlying the humor response.

Acknowledgments

The author would like to thank Fabienne Wicki, Ivana von Weissenfluh, Andreas Riederer and Patrick Lüthold who helped to find participants for this study and Michael Hegenloh for coding the explanations for interrater reliability. Many thanks to Oswald Huber and Odilo W. Huber for helpful comments on previous versions of this paper and to Aikaterini Stefanidi for proof-reading. Finally, I would also like to thank Simon Baron-Cohen for the permission to use his questionnaires.

Note

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