Nonliteral language processing across the lifespan[☆]

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ARTICLE INFO

ABSTRACT

Studies investigating the effects of aging on nonliteral language processing have mainly focused on one sensory modality, for example written vignettes. In the current study, we used a video-based task to examine the effect of healthy aging on social communication perception using a novel database called RISC (Relation Inference in Social Communication). By means of an online recruitment platform, we asked young, middle-aged, and older adults between the ages of 18 and 76 ($N = 100$) to evaluate videos of actors using different forms of literal and nonliteral language, such as sarcasm or teasing. The participants' task was to infer the speakers' belief and the speakers' intention. Older participants demonstrated lower accuracy in discriminating nonliteral from literal interactions compared to younger and middle-aged groups. When evaluating speaker intentions, older adults judged sarcasm as friendlier compared to literal negative utterances. We also found that the older the participant, the more difficulty they have identifying teasing as insincere. Our results expand on age-related similarities and differences in evaluating speaker intentions and demonstrate the practicality of the RISC database for studying nonliteral language across the lifespan.

1. Social communication across the lifespan

To accurately process social information during communication, it is important to be able to interpret other people's feelings, intentions, and attitudes. Understanding what other people think and feel enables us to navigate social environments and helps us to partake in meaningful interactions and maintain social relationships. The maintenance of functional communication skills over the life span is essential and a crucial social determinant of healthy aging (Yorkston et al., 2010). Social communication difficulties can limit functional capacities and quality of life (L.H. Phillips et al., 2015) and can lead to substantial declines in social participation (Bailey et al., 2008). Thus, it is important to determine the factors that underlie the effects of aging on social communication skills.

The current study examines high-level, pragmatic language processing in the form of nonliteral language (e.g., sarcasm) using a naturalistic, dynamic task. Nonliteral language, such as irony or sarcasm, is omnipresent in daily life and requires a cautious interpretation of a speaker's intention, the integration of linguistic and paralinguistic

information, as well as emotion reading and perspective taking. An important aspect of everyday nonliteral language is its multimodality. During face-to-face communication, speakers use an array of visual and auditory cues to express indirect meanings. In most cases, the recognition of nonverbal information such as tone of voice, facial expression, and body language is crucial for understanding nonliteral utterances. Deficits in understanding nonliteral language occur in many neurological, developmental, and psychiatric disorders (e.g., Cassel, McDonald, Kelly, & Togher, 2019) and can lead to difficulties interacting with friends and family, functioning in a working environment, and maintaining an active social life (Holtgraves & Cadle, 2016). Besides clinical conditions, cognitive aging can also affect the ability to understand nonliteral language in social conversation (e.g., Phillips et al., 2015).

1.1. Aging and social communication

The recognition of nonverbal social and emotional cues, such as the processing of emotional prosody (e.g., Allen & Brosgole, 1993; Kiss & Ennis, 2001; Mitchell, 2007; Orbelo et al., 2003; Orbelo et al., 2005) and

pragmatic forms of meaning (for a review see Phillips et al., 2014), has been shown to change with age. Specifically, the processing of humor and nonliteral language has been reported to decline in later stages of life (Halberstadt et al., 2011; Phillips et al., 2015; Shammi & Stuss, 2003; Uekermann et al., 2008). Deficits that lead to improper interpretation of nonliteral language can lead to difficulties communicating and interacting in everyday social settings (Elamin et al., 2012). Thus, it is important to study how aging impacts the comprehension of nonliteral language in healthy and brain-damaged populations, which in turn will allow for the development of better diagnostic and therapeutic tools that focus on these skills.

In a recent study testing age-related differences in the perception of emotion in speech, Ben-David et al. (2019) showed that older adults rely more on semantics rather than prosody when trying to identify emotional content of speech. By possibly relying more on semantics, older adults may have difficulties in understanding the ambiguous nature of nonliteral language which relies on speech intonation and nonverbal cues. If this is the case, making sense of sarcasm and teasing can present challenges to older participants, as has been found in a study by Phillips et al. (2015). In their study, older adults were less successful in comprehending both written and audio-visual sarcastic exchanges compared to younger and middle-aged adults. They related these results to previous findings regarding age-related decline in the perception of emotional expressions (Ruffman et al., 2008) and perspective taking (Henry et al., 2013). Similarly, Pomareda et al. (2019) found an effect of healthy aging on the understanding of nonliteral language, with a particular deficit in processing teasing statements.

While Pomareda et al. (2019) used written stories as stimuli, Phillips et al. (2015) used the *The Awareness of Social Inference Test* (TASIT, McDonald et al., 2003), a video based social cognition task that was developed to test social awareness in individuals with traumatic brain injuries. The TASIT has been successfully applied in several studies investigating the effect of aging on identifying speaker intention and Theory of Mind (Burdon, Dipper, & Cocks, 2016; Lavrencic et al., 2016; Grainger et al., 2019); in general, this research revealed that aging negatively influences performance on the TASIT. Other commonly used tasks that target social cognition include the Social Faux Pas Recognition Tasks (Baron-Cohen et al., 1999) and the Second Order False Belief Order Task (Perner & Wimmer, 1985). In contrast to the TASIT, these tasks do not specifically test nonliteral language and do not entail video materials.

While the TASIT is a very reliable and productive tool to test the understanding of nonliteral language under ecologically valid conditions, it does not offer the possibility of directly comparing speaker intentions that only differ in their nonverbal cues, or a control of the lexical-semantic content depicted in the social interactions. Additionally, the TASIT was recorded using Australian English, which could influence the performance of participants who are unfamiliar with the accent.

1.2. The RISC database

Inspired by the TASIT (McDonald et al., 2003), we created a new tool that includes manipulations of the relationship between communication partners, controlled lexical content across intentions, as well as a larger collection of videos to be able to conduct experiments that require a large number of experimental trials. The Relational Inference of Social Communication database (RISC; Rothermich & Pell, 2015) provides ecologically valid video stimuli to study social communication in healthy and brain-damaged individuals (see screenshots in Fig. 1). The RISC database entails 600 dynamic video vignettes of actors in everyday type scenarios employing realistic nonverbal social cues; it focuses on different types of speaker intentions such as sincere, teasing, prosocial lies, and sarcasm.

The importance of exploring the RISC in older adults is highlighted by a systematic review by Love et al. (2015). Love and colleagues (2015)

found that limitations in experimental paradigms, especially concerning the lack of capturing naturalistic social cues, created barriers in understanding the effect of age on social cognition - despite changes in functional connectivity that should *predict* such changes. Moreover, studies have shown that age and situational context interact during emotion regulation and processing. A number of studies report that older adults divert attention away from negative aspects of a scene, even in low-intensity negative contexts, showing preference toward positive aspects of a scene/face in a way that may influence their emotional regulation (e.g., Isaacowitz et al., 2006; Noh et al., 2011; Scheibe et al., 2015; for a review see Gonçalves et al., 2018; Ruffman et al., 2008). These studies underscore the importance of examining social-emotional cues relative to speaker intent in a contextualized task, and across varying speaker intents and emotional states. The current exploratory analysis is an important step in filling this gap and advancing the understanding of social cognition changes in aging (Love et al., 2015; Hess and Blanchard-Fields, 1999; T.M. Hess and Pullen, 1994).

As mentioned earlier, one advantage of the RISC database is that the lexical-semantic content of different statements is highly controlled, and the speaker's intention must be deducted from nonverbal cues, such as facial expressions, tone of voice, and body language. For the current experiment, we focus on literal positive, literal negative, sarcastic, and teasing interactions. Teasing is described here as a negatively worded statement that is meant to be taken positively, accompanied by friendly facial and vocal cues (Keltner et al., 2001). In the RISC database, teasing mainly manifests as an "ironic compliment," for example, someone saying, "You did a terrible job!" to a person who actually did a great job. Teasing statements are typically exchanged between close friends and are intended to communicate humorous aggression and affiliation (Giora, Drucker, Fein, & Mendelson, 2015; Lampert & Ervin-Tripp, 2006; Seckman & Couch, 1989). Sarcasm, on the other hand, typically comprises a positive statement that has a negative or criticizing intention. It is commonly accompanied by acoustic markers such as changes in intonation (Cheang & Pell, 2008) and body language, such as eye rolling (Attardo et al., 2003). The suggested social functions of sarcasm range from demonstrating a form of criticism, alleviating the aggressiveness of a critical statement, or to being humorous (e.g., Caucci & Kreuz, 2012; S. Dews et al., 1995; Jorgensen, 1996).

While teasing and sarcasm may seem like complementary forms of speaker intention, they differ in at least two ways: how often they are typically used in daily life, and how easily they are interpreted when performing a task. More specifically, sarcasm is more common than teasing and is also identified faster and with higher accuracy (Caillies et al., 2019; Clark & Gerrig, 1984; Hancock et al., 2000; M. Harris & Pexman, 2003; Matthews et al., 2006; Sperber & Wilson, 1981). Within the RISC inventory, teasing and sarcasm represent the nonliteral statements that are contrasted with literal positive and negative statements. Importantly, literal negative and teasing statements as well as literal positive and sarcastic statements have identical lexical content, and the speakers' true intentions are only communicated via nonverbal cues.

1.3. The current study

While the RISC database has been validated to capture social communication abilities in young adults (Rothermich & Pell, 2015), it has not been validated in groups of middle-aged or older adults. The database has been developed to provide a highly constructive tool to study the interpretation of speaker intentions in both healthy adults and clinical populations, such as Parkinson's Disease or People with Aphasia. Given the age range associated with these specific populations, gaining information about how participants in different age groups react to these types of stimuli is crucial. Examining the RISC in these age groups fills a critical gap highlighted by a systematic review from Love and colleagues (2015) who concluded that the lack of naturalistic tasks in studies of social cues encoding and processing has hindered research in social cognition and aging. Exploring the use of the RISC database in older

adults is important for advancing understanding of the trajectory of social cognition development across the lifespan. The latter point is of particular importance given that social cognition impairments can be salient in neurodegenerative disorders that disproportionately affect older adults (e.g., Bediou et al., 2009; Roberts et al., 2017; Snowden et al., 2003).

Our main prediction is that the ability to comprehend and evaluate nonliteral language is reduced in older adults compared to younger and middle-aged adults (Phillips et al., 2015; Pomareda et al., 2019). Based on previous results (Pomareda et al., 2019), we expect that older adults will have a harder time identifying teasing compared to other intentions.

2. Method

2.1. Participants

In total, 119 adults (see Table 1 for details) took part in the current study. Inclusion criteria included English as native language, a minimum of 18 years of age, and US residency at the time of testing. Nineteen participants had to be excluded due to self-reported hearing problems ($n = 16$), self-reported dementia ($n = 1$), and missing data ($n = 2$). Of the remaining 100 participants, 38 were grouped as young adults (22 female, age 18–39), 29 were labeled middle-aged adults (17 female, age 40–59), and 33 were referred to as older adults (21 female, age 60–79). Age range cutoffs for the three groups were derived from previous literature (Phillips et al., 2015) assessing social decoding in a life span sample. All remaining participants self-reported the absence of a dementia diagnosis, a mild cognitive impairment diagnosis, and intact or corrected visual and auditory functioning. The study was approved by the local ethics review board. Participants were recruited through Prolific Academic, a research participant recruiting database (http://prolific.ac), and participants gave consent via a digital signature before starting the experiment. Participants received $13.50 as monetary compensation.

2.2. Stimulus materials, task and procedures

The video experiment was created using the Research Electronic Data Capture tool (REDCap), which is hosted online by Vanderbilt University (Harris et al., 2009). We presented participants with 192 videos (between 3 and 20 s in total length) taken from the RISC database depicting four different intentions: literal positive, literal negative, sarcasm and teasing. The 192 videos were chosen as a representative subset of the 600 videos available in the database in order to keep the length of the experiment manageable for the participants. In these videos, four native English-speaking actors (two male, two female; $mean_{age}$ in years = 19.50, $SD = 0.50$) performed in the scenes. Each scene includes two actors: one male/male, one female/male, and two female/male dyads.

In all videos, one actor poses a question to their paired interlocutor (e.g., "Would you like one of the cookies I just made?"), that is followed by a response from the second actor that could either be positive ("Mmmh, they look so good!") or negative ("They don't look very appetizing."; see Fig. 1 and Appendix for details). Positive responses were expressed in a literal positive manner or sarcastically, while negative responses were delivered in a literal negative (blunt) or teasing manner. The vignettes portrayed eleven different scenes (e.g., painting or gift, see Appendix for more examples) in four possible relationships (couple, friends, boss/employee or colleagues; 4 intentions × 12 scenes × 4 relationships = 192 trials). In order to provide a research inventory with high ecological validity, the RISC stimuli were designed to include a multitude of cues, such as facial expressions, gaze, gestures, and body language. Thus, the videos entail a number of spontaneous indicators corresponding to different intentions. For example, teasing utterances are usually accompanied by laughter, a common communicative strategy to assure that the negative content of the message is not taken literally (e.g., Lampert & Ervin-Tripp, 2006). Similarly, the actors in the videos use an array of auditory and visual cues to signal sarcasm, such as eye rolling, fake accents, and fundamental frequency changes (Rothermich & Pell, 2015).

To familiarize participants with the four actors and their names, an introductory video (53 s in length) was presented at the beginning of the experiment. Before starting the experiment, participants completed a training task that included four practice trials. Participants watched each practice video trial and were then prompted to answer two questions about speaker belief ("Did Anna like the cookies?" - *Yes/No*) and speaker intention ("How friendly was Anna trying to be?" judged on a 5-point Likert scale; 1 = *not friendly at all*, 5 = *very friendly*). The speaker belief question tapped into the understanding of the *assertive* intent of the speaker, i.e., the sincerity of her statement, while the speaker intent question tappped into the *expressive* intent of the speaker, i.e., what was Anna's affective intention (for example, to be friendly; Haverkate, 1990). The experiment lasted about 75 min. We created four different randomization lists consisting of all 192 stimuli that were presented in a pseudo-randomized fashion to avoid order effects or differences due to fatigue. The participants had frequent options to take breaks.

2.3. Data analysis

All data were analyzed using Linear Mixed Effects Models in R (R Core Team, 2017) and the lme4 package (Bates et al., 2014). While there is some debate in the literature as to the best approach for analyzing ordinal data such as Likert scales (Kizach, 2014), the risk of finding false positives (Type 1 error) is higher for ordinal data analysis methods compared to the linear mixed-effects method (Kizach, 2014; Norman, 2010). We applied the Satterthwaite (1946) approximation for computing *p*-values for *t*-statistics, as implemented in the lmerTest package version 2.0-6 (Kuznetsova et al., 2017). Separate LME models were built for dependent variables of accuracy to identify speaker belief and ratings of the friendliness of the speaker.

In all cases, we first defined a base model, which included only one random effect (Subject); refined models were then identified by performing comparisons using the ANOVA function in R. This was done to examine whether each new random/fixed effect improved model fit; if they did not improve the model, they were not included. Our fixed effects (or independent variables) included Intention (literal positive, literal negative, sarcasm, teasing) and Age Group (younger age, middle-aged, old age). Random effects included intercepts for Participants, Scenes, and Lists. Models were compared based on χ^2, Akaike information criterion (*AIC*; Bozdogan, 1987), *z*-values, and *p*-values. The AIC is an estimator of the relative quality of statistical models for a given set of data and provides a means for model selection. Multiple comparisons were adjusted using Tukey's Multiple Contrasts (part of R package "emmeans"; Lenth, 2018) for post-hoc testing. To examine the relationship among age, speaker belief and speaker intention, we calculated Pearson's correlation coefficients across all variables (significance level = $p < 0.05$).

Table 1
Participant characteristics.

	Young adults		Middle-aged adults		Older adults	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Sample size	38	*NA*	29	*NA*	33	*NA*
Sex (F/M)	21/17	*NA*	17/12	*NA*	20/13	*NA*
Age (years)	27.89	5.02	47.03	5.70	64.18	4.67
Education (years)	12.6	3.65	13.8	3.64	13.7	3.36

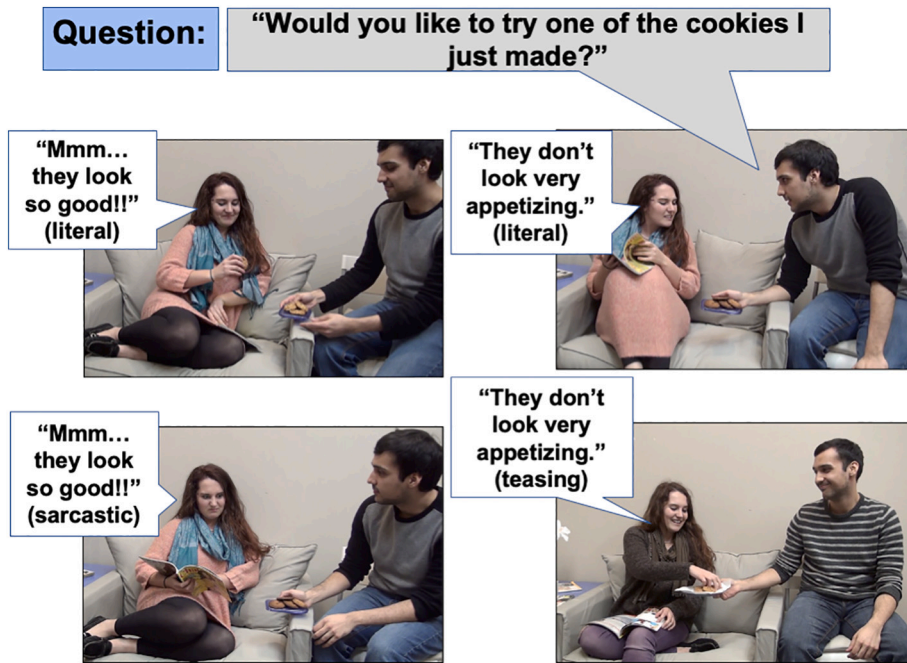*Note.* Descriptive information for all three age groups.

Fig. 1. Example social interactions (video screenshots).

3. Results

3.1. Speaker belief task

Overall, participants had high accuracy scores when identifying

speaker belief ($M = 0.85$, SD $= 0.35$; see Fig. 2) and we found a significant difference when comparing the base model to an Intention model (see Table 2 for details). Post-hoc comparisons showed that speaker belief for literal negative remarks was identified with higher accuracy than for literal positive, sarcasm, and teasing utterances.
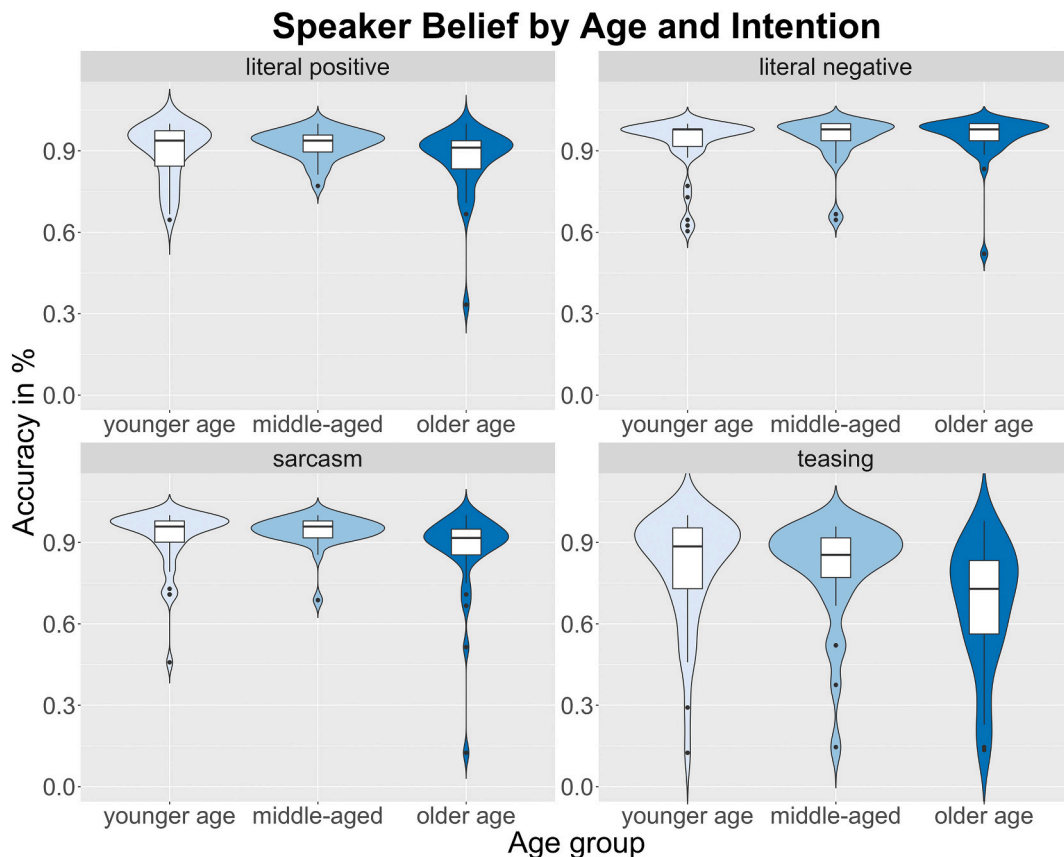

Fig. 2. Violin plots (combining density plots and boxplots) showing accuracy results (in percentage) for each speaker intention and age group.

Table 2

LMER model and post-hoc results for the speaker belief task. Italics indicate significant results. *P*-values were adjusted using the tukey method.

Models	AIC	Chisq	p value
Speaker belief accuracy ~ 1 + (1|Subject) + (1|Scene), family = binomial	10,278		
Speaker belief accuracy ~ Intention + (1|Subject) + (1|Scene), family = binomial	9436	848.91	<0.0001
Speaker belief accuracy ~ Intention*Age + (1|Subject) + (1|Scene), family = binomial	9317	134.93	<0.0001

Post hoc comparisons – Intention	ß	z-ratio	p value
Literal negative - literal positive	0.041	−37.95	<0.0001
Literal negative – sarcasm	0.028	−55.21	0.0001
Literal negative – teasing	0.173	−13.94	<0.0001
Literal positive – sarcasm	−0.013	−35.87	0.1398
Literal positive – teasing	0.131	−23.46	<0.0001
Sarcasm – teasing	0.145	−37.95	<0.0001

Post hoc comparisons – Age*Intention	ß	z-ratio	p value
Intention = literal negative			
Middle-aged - older age	−0.008	−0.33	0.9398
Middle-aged - younger age	0.018	0.75	0.7289
Older age - younger age	0.026	1.13	0.4898
Intention = literal positive			
Middle-aged - older age	0.061	2.44	0.0383
Middle-aged - younger age	0.023	0.97	0.5901
Older age - younger age	−0.037	−1.60	0.2447
Intention = sarcasm			
Middle-aged - older age	0.072	2.91	0.01
Middle-aged - younger age	0.023	0.96	0.6017
Older age - younger age	−0.049	−2.12	0.0858
Intention = teasing			
Middle-aged - older age	0.126	5.08	<0.0001
Middle-aged - younger age	−0.007	−0.31	0.9459
Older age - younger age	−0.134	−5.75	<0.0001

Sarcastic scenes were identified more easily than literal positive interactions and teasing. Compared to literal positive scenes, participants were less accurate when identifying teasing interactions. There was no significant difference in accuracy between literal positive and sarcasm scenes.

The Intention model was significantly improved using a model containing an interaction between Intention and Age (see Fig. 2 and Table 2). Resolving the interaction for Age Group by Intention revealed significant differences in accuracy for literal positive scenes, with higher accuracy for middle-aged compared to older adults. We found a similar difference for sarcasm scenes between middle-aged and older adults, with higher accuracy for middle-aged adults. The identification of speaker belief was also significantly different for teasing interactions when comparing middle-aged and older adults (middle-age > older age) as well as older and younger adults (younger age > older age).

3.2. Speaker intention task

The Likert scale ratings of friendliness (see Fig. 3 and Table 3) of speaker revealed a significant main effect of including Intention in the model (sarcasm < literal negative < teasing < literal positive) versus the base model. Post-hoc comparisons reveal higher friendliness ratings for literal positive compared to literal negative, sarcasm, and teasing scenes. Ratings were also significantly higher for literal negative versus sarcasm interactions as well as for teasing compared to literal negative and sarcasm scenes.

A significant effect was found when comparing the Intention model with a model containing an interaction between Intention and Age (see Fig. 3 and Table 3). For sarcastic remarks, we found higher friendliness ratings for older compared to middle-aged and younger participants,

and higher friendliness ratings for middle-aged compared to younger participants. Resolving the interaction for Age by Intention also revealed significantly higher friendliness ratings for teasing interactions in middle-aged versus younger adults.

3.3. Correlation analysis

We examined the relationship between age and identifying speaker intentions and found that accuracy identifying teasing statements correlated negatively with age ($r = -0.21$, $p = 0.0308$), revealing that the older an individual, the greater the difficulty of identifying a of inteasing as insincere. No significant correlations were found for the other intentions ($p > 0.05$).

4. Discussion

The current study examined the influence of healthy aging on processing nonliteral language using the novel video database RISC. Overall, older adults performed with lower accuracy scores when identifying nonliteral language compared to young and middle-aged adults, especially for teasing interactions. Additionally, older adults tended to interpret sarcastic interactions with a friendly demeanor compared to the other age groups.

Our data generally showed that participants displayed more accuracy when identifying literal negative, literal positive, and sarcastic statements compared to teasing statements. This is further confirmed by a negative correlation between speaker belief accuracy for teasing and age. The higher accuracy for identifying literal statements is a replication of findings in earlier studies using the RISC inventory (Jakobson et al., 2018; Rothermich & Pell, 2015) and can in part be explained by a so-called *truth bias*, which suggests that humans are inclined to operate on the default assumption that what the other person says is essentially honest (Levine, 2014). Thus, it is possible that participants were biased to assume that the actor or actress was being literal, since that is assumed assume to be the unmarked, default intention. We also found differences in accuracy between the three age groups, but only for nonliteral exchanges (i.e., sarcasm and teasing). This result corresponds to previous research and has been related to a reduced ability to identify affective cues from faces, voices, and gestures, which seem to be mediated by emotion perception in older adults (Phillips et al., 2015).

Our results add to this existing literature by providing evidence for the ability of older adults to infer nonliteral language when the stimuli are controlled for semantic content. Additionally, our study is the first to use dynamic video stimuli that include both positive (teasing) and negative (sarcasm) forms of nonliteral language. While Pomareda et al. (2019) included both forms in their study, they used written stimuli which did not contain the multimodal cues which we focus on in our study. Using ecologically valid dynamic videos, the present data revealed that positively valenced forms of nonliteral language (teasing) represent a challenge for older adults, but not for middle-aged or younger adults.

The results pertaining to speaker intentions also revealed that older adults judge sarcasm as friendlier compared to middle-aged and younger adults, possibly due to difficulties in identifying a speaker's beliefs. If an older individual did not identify a sarcastic statement as conveying a negative attitude, they might have been more inclined to evaluate the statement as friendly. These results add to recent evidence showing that older adults have specific difficulties with identifying teasing statements, and sometimes even fail to evaluate the underlying intention (Pomareda et al., 2019). It is also possible that our group of older adults based their decisions on different interpretations of communicative cues compared to the middle-aged or younger group, or that familiarity played a role. Giora (1997) suggests that sarcasm is more common than teasing in daily conversations and might therefore be more difficult to process cognitively (see also Pomareda et al., 2019).

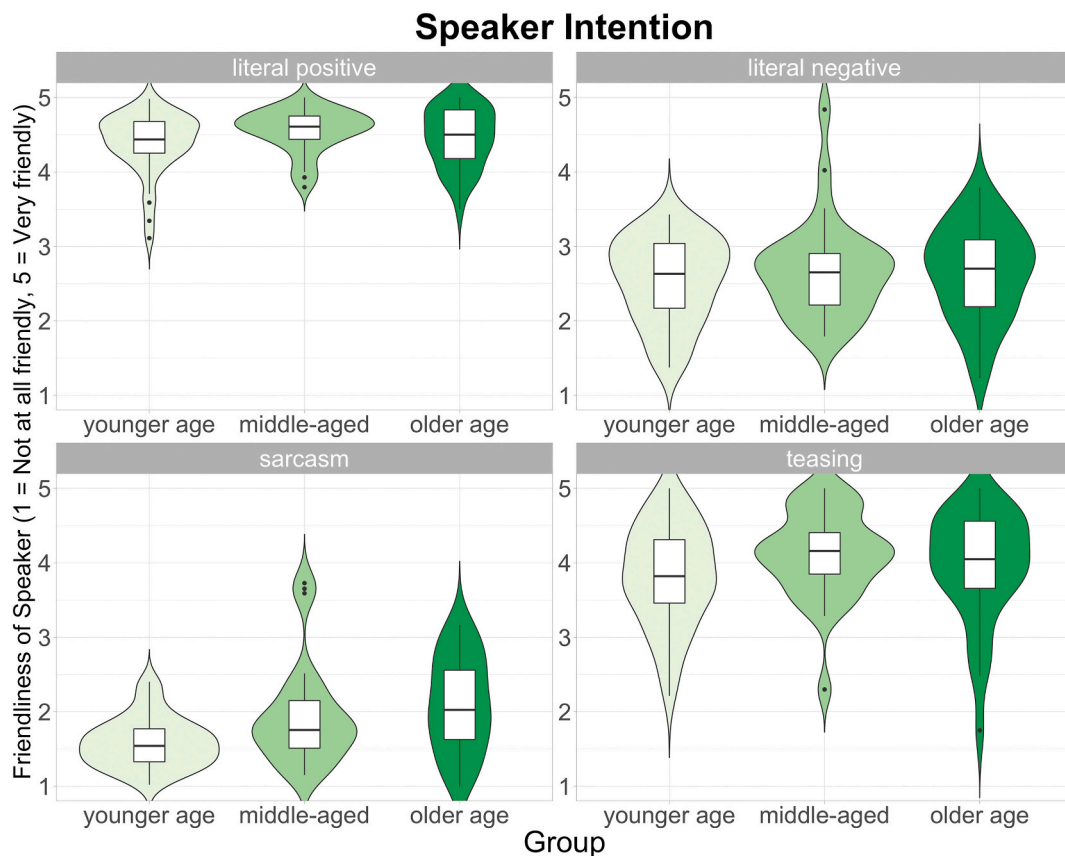In contrast to some previous studies investigating the effect of aging

Fig. 3. Violin plots (combining density plots and boxplots) showing friendliness ratings (Likert scale) for each speaker intention and age group.

on nonliteral language perception (e.g., Burdon et al., 2016; Lavrencic et al., 2016; Pomareda et al., 2019), we included a middle-aged group into our analysis. The middle-aged group in the current study mostly behaved like the young adults group, confirming the results found in the study using the TASIT video task (Phillips et al., 2015). This suggests that the ability to understand and interpret negative (sarcasm) and positive (teasing) intentions is preserved into older age. It has been implied that while emotion perception seems to decline in middle age (Mill et al., 2009), more complex aspects of social cognition such as identifying speaker intent seem to only occur later in life (Phillips et al., 2015). Additionally, it is possible that social cognition is also influenced by context (e.g., Noh et al., 2011) and experimental task demands (e.g. Henry et al., 2013), which might interact in complex ways with age.

Overall, our findings indicate that older adults may be more susceptible to decision-making difficulties in contexts that rely on the accurate discernment of social cues (e.g., advertising). The observed difficulties in recognizing literal and nonliteral statements in older adults may be explained by the "frontal aging hypothesis" (Uekermann et al., 2006; West & Covell, 2001). It links deficits in working memory, inhibition, and abstract thinking to age-related plasticity changes in the prefrontal cortex, which are assumed to impact one's ability to interpret facial expressions and other social cues (e.g., Shammi and Stuss, 2003; Sullivan & Ruffman, 2004; Halberstadt et al., 2011; El Haj & Antoine, 2018; Uekermann et al., 2008). For future research, adding cognitive and neuropsychological measurements would allow one to test the influence of specific cognitive domains on social communication in older adults.

One of the limitations of our study is that participants gave us information about their cognitive status via self-report, so we cannot completely rule out the presence of mild cognitive impairment in the aging cohort. While we do not think this was the case, future studies will profit from in-depth cognitive and neuropsychological assessments.

Additionally, the number of items per speech act type is unbalanced in the current study and this may have skewed the data (see Appendix). While some items are formulated relating to the speaker in the first person ("Would you like some of the cookies I just made?"), other items ask about the inferred state of others ("Do you think people will like my cake?"). Future studies should control for the type of speech act and examine if there are differences in ratings based on this distinction. Finally, our older adult sample is rather young, with a mean age of 64, which is close to the middle-age range. This was in part due to the skewed age range in the participant pool available through Prolific Academic. As per data from the website (https://www.prolific. co/demographics/; accessed on 09/02/2020), about 50% of people in the pool are between 20 and 30 years old, while adults over 60 years of age make up around 3% of the pool. Future studies will need to include adults in broader age ranges by using other means of recruitment.

5. Conclusions

Our findings are consistent with the idea that age-related differences impact the processes involved in evaluating social intentions (Phillips et al., 2015; Pomareda et al., 2019; Burdon, Dipper, & Cocks, 2016; Lavrencic et al., 2016; Grainger et al., 2019). Overall, young adults and middle-aged adults were able to correctly distinguish literal from nonliteral interactions. However, older adults had more difficulties identifying teasing stimuli as nonliteral, which is in line with previous studies (Pomareda et al., 2019). The results reveal the potential of the RISC database for use as a sensitive research tool for studying social communication in adults and in age-related neurodegenerative disorders such as Parkinson's disease (Pell et al., 2014) and frontotemporal dementia (Kipps et al., 2009). Future studies will focus on the development of assessments and interventions that improve social communication abilities in older adults, especially in those with clinical

Table 3

LMER model and post-hoc results for the speaker intention task. Italics indicate significant results. P-values were adjusted using the tukey method.

Models	AIC	Chisq	p value
Speaker intention ~1 + (1|Subject) + (1|Scene)	56,246		
Speaker intention ~ Intention + (1|Subject) + (1| Scene)	40,017	16,229	<0.0001
Speaker intention ~ Intention*Age + (1| Subject) + (1|Scene)	39,814	202.26	<0.0001

Post hoc comparisons – Intention	ß	z-ratio	p value
Literal negative - literal positive	−1.853	−105.71	<0.0001
Literal negative – sarcasm	0.761	43.52	<0.0001
Literal negative – teasing	−1.401	−76.21	<0.0001
Literal positive – sarcasm	2.614	147.97	<0.0001
Literal positive – teasing	0.453	24.41	<0.0001
Sarcasm – teasing	−2.162	−117.21	<0.0001

Post hoc comparisons – Age*Intention	ß	z-ratio	p value
Intention = literal negative			
Middle-aged - older age	−0.008	−0.33	0.9398
Middle-aged - younger age	0.018	0.75	0.7289
Older age - younger age	0.026	1.13	0.4898
Intention = literal positive			
Middle-aged - older age	0.061	2.44	0.0383
Middle-aged - younger age	0.023	0.97	0.5901
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Intention = sarcasm			
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conditions.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2020.103213.

CRediT authorship contribution statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of competing interest

None.

References

Allen, R., & Brosgole, L. (1993). Facial and auditory affect recognition in senile geriatrics, the normal elderly and young adults. *International Journal of Neuroscience, 68*(1–2), 33–42.

Attardo, S., Eisterhold, J., Hay, J., & Poggi, I. (2003). Multimodal markers of irony and sarcasm. *Humor, 16*(2), 243–260.

Bailey, P. E., Henry, J. D., & von Hippel, W. H. (2008). Empathy and social functioning in late adulthood. *Aging & Mental Health, 12*, 499–503. https://doi.org/10.1080/13607860802224243

Baron-Cohen, S., O'riordan, M., Stone, V., Jones, R., & Plaisted, K. (1999). Recognition of faux pas by normally developing children and children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders, 29*(5), 407–418.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using lme4. arXiv preprint arXiv:1406.5823.

Bediou, B., Ryff, I., Mercier, B., Milliery, M., Henaff, M. A., D'Amato, T., … Krolak-Salmon, P. (2009). Impaired social cognition in mild Alzheimer disease. *Journal of Geriatric Psychiatry and Neurology, 22*(2), 130–140.

Ben-David, B. M., Gal-Rosenblum, S., van Lieshout, P. H., & Shakuf, V. (2019). Age-related differences in the perception of emotion in spoken language: The relative roles of prosody and semantics. *Journal of Speech, Language, and Hearing Research, 62*(4S), 1188–1202.

Bozdogan, H. (1987). Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. *Psychometrika, 52*(3), 345–370.

Burdon, P., Dipper, L., & Cocks, N. (2016). Exploration of older and younger British adults' performance on The Awareness of Social Inference Test (TASIT). *International Journal of Language & Communication Disorders, 51*(5), 589–593.

Caillies, S., Gobin, P., Obert, A., Terrien, S., Coutté, A., Iakimova, G., & Besche-Richard, C. (2019). Asymmetry of affect in verbal irony understanding: What about the N400 and P600 components? *Journal of Neurolinguistics, 51*, 268–277.

Cassel, A., McDonald, S., Kelly, M., & Togher, L. (2019). Learning from the minds of others: A review of social cognition treatments and their relevance to traumatic brain injury. *Neuropsychological Rehabilitation, 29*(1), 22–55.

Caucci, G. M., & Kreuz, R. J. (2012). Social and paralinguistic cues to sarcasm. *Humor, 25*(1), 1–22.

Cheang, H. S., & Pell, M. D. (2008). The sound of sarcasm. *Speech Communication, 50*(5), 366–381.

Clark, H. H., & Gerrig, R. J. (1984). On the pretense theory of irony. *Journal of Experimental Psychology: General, 113*, 121–126.

Dews, S., Kaplan, J., & Winner, E. (1995). Why not say it directly? The social functions of irony. *Discourse Processes, 19*(3), 347–367.

El Haj, M., & Antoine, P. (2018). Relationship between lower tendency to deceive in aging and inhibitory compromise. *Gerontology, 64*(1), 67–73.

Elamin, M., Pender, N., Hardiman, O., & Abrahams, S. (2012). Social cognition in neurodegenerative disorders: a systematic review. *J Neurol Neurosurg Psychiatry*, jnnp-2012.

Giora, R. (1997). Understanding figurative and literal language: The graded salience hypothesis. *Cognitive Linguistics (includes Cognitive Linguistic Bibliography), 8*(3), 183–206.

Giora, R., Drucker, A., Fein, O., & Mendelson, I. (2015). Default sarcastic interpretations: On the priority of nonsalient interpretations. *Discourse Processes, 52*(3), 173–200.

Gonçalves, A. R., Fernandes, C., Pasion, R., Ferreira-Santos, F., Barbosa, F., & Marques-Teixeira, J. (2018). Effects of age on the identification of emotions in facial expressions: A meta-analysis. *PeerJ, 6*, Article e5278.

Grainger, S. A., Steinvik, H. R., Henry, J. D., & Phillips, L. H. (2019). The role of social attention in older adults' ability to interpret naturalistic social scenes. *Quarterly Journal of Experimental Psychology, 72*(6), 1328–1343.

Halberstadt, J., Ruffman, T., Murray, J., Taumoepeau, M., & Ryan, M. (2011). Emotion perception explains age-related differences in the perception of social gaffes. *Psychology and Aging, 26*(1), 133.

Hancock, J. T., Dunham, P. J., & Purdy, K. (2000). Children's comprehension of critical and complementary forms of verbal irony. *Journal of Cognition and Development, 1*(2), 227–248.

Harris, M., & Pexman, P. M. (2003). Children's perceptions of the social functions of verbal irony. *Discourse Processes, 36*(3), 147–165.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research Electronic Data Capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42*(2), 377–381.

Haverkate, H. (1990). A speech act analysis of irony. *Journal of Pragmatics, 14*(1), 77–109. A speech act analysis of irony.

Henry, J. D., Phillips, L. H., Ruffman, T., & Bailey, P. E. (2013). A meta-analytic review of age differences in theory of mind. *Psychology and Aging, 28*(3), 826.

Hess, T. M., & Blanchard-Fields, F. (Eds.).. (1999). *Social cognition and aging*. Elsevier.

Hess, T. M., & Pullen, S. M. (1994). Adult age differences in impression change processes. *Psychology and Aging, 9*(2), 237.

Holtgraves, T., & Cadle, C. (2016). Communication impairment in patients with Parkinson's disease: Challenges and solutions. *J. Parkinsonism Restless Legs Syndr, 6*, 45–55.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006). Selective preference in visual fixation away from negative images in old age? An eye-tracking study. *Psychology and Aging, 21*(1), 40.

Jakobson, L. S., Pearson, P. M., Kozub, Z., Hare, C., & Rigby, S. N. (2018). Links between traits associated with the broad autism phenotype and empathy and young adults' ability to decode speaker intentionality. *Research in Autism Spectrum Disorders, 50*, 11–21.

Jorgensen, J. (1996). The functions of sarcastic irony in speech. *Journal of Pragmatics, 26*(5), 613–634.

Keltner, D., Capps, L., Kring, A. M., Young, R. C., & Heerey, E. A. (2001). Just teasing: A conceptual analysis and empirical review. *Psychological Bulletin, 127*(2), 229.

Kipps, C. M., Nestor, P. J., Acosta-Cabronero, J., Arnold, R., & Hodges, J. R. (2009). Understanding social dysfunction in the behavioural variant of frontotemporal dementia: The role of emotion and sarcasm processing. *Brain, 132*(3), 592–603.

Kiss, I., & Ennis, T. (2001). Age-related decline in perception of prosodic affect. *Applied Neuropsychology, 8*(4), 251–254.

Kizach, J. (2014). *Analyzing Likert-scale data with mixed-effects linear models: A simulation study* (Poster Presented at Linguistic Evidence).

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package:tests in linear mixed effects models. *Journal of Statistical Software*, 82(13).

Lampert, M. D., & Ervin-Tripp, S. M. (2006). Risky laughter: Teasing and self-directed joking among male and female friends. *Journal of Pragmatics, 38*(1), 51–72.

Lavrencic, L. M., Kurylowicz, L., Valenzuela, M. J., Churches, O. F., & Keage, H. A. (2016). Social cognition is not associated with cognitive reserve in older adults. *Aging, Neuropsychology, and Cognition, 23*(1), 61–77.

Lenth, R. (2018). Emmeans: Estimated marginal means, aka least-squares means. *R Package Version, 1*(2).

Levine, T. R. (2014). Truth-default theory (TDT) a theory of human deception and deception detection. *Journal of Language and Social Psychology, 33*(4), 378–392.

Love, M. C. N., Ruff, G., & Geldmacher, D. S. (2015). Social sognition in older adults: A review of reuropsychology, neurobiology, and functional connectivity. *Medical & Clinical Reviews, 1*, 1–6.

Matthews, J. K., Hancock, J. T., & Dunham, P. J. (2006). The roles of politeness and humor in the asymmetry of affect in verbal irony. *Discourse Processes, 41*, 3–24.

McDonald, S., Flanagan, S., Rollins, J., & Kinch, J. (2003). TASIT: A new clinical tool for assessing social perception after traumatic brain injury. *The Journal of Head Trauma Rehabilitation, 18*(3), 219–238.

Mill, A., Allik, J., Realo, A., & Valk, R. (2009). Age-related differences in emotion recognition ability: A cross-sectional study. *Emotion, 9*(5), 619.

Mitchell, R. L. (2007). Age-related decline in the ability to decode emotional prosody: Primary or secondary phenomenon? *Cognition and Emotion, 21*(7), 1435–1454.

Noh, S. R., Lohani, M., & Isaacowitz, D. M. (2011). Deliberate real-time mood regulation in adulthood: The importance of age, fixation and attentional functioning. *Cognition & Emotion, 25*(6), 998–1013.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education, 15*(5), 625–632.

Orbelo, D., Testa, J., & Ross, E. (2003). Age-related impairments in comprehending affective prosody with comparison to brain damaged sub- jects. *Journal of Geriatric Psychiatry andNeurology, 16*, 44–45.

Orbelo, D. M., Grim, M., Talbott, R., & Ross, E. (2005). Impaired comprehension of affective prosody in elderly subjects is not predicted by age-related hearing loss or age-related cognitive decline. *Journal of Geriatric Psychiatry and Neurology, 18*, 25–32. https://doi.org/10.1177/0891988704272214

Pell, M. D., Monetta, L., Rothermich, K., Kotz, S. A., Cheang, H. S., & Mcdonald, S. (2014). Social perception in adults with Parkinson's disease. *Neuropsychology, 28*(6), 905–916.

Perner, J., & Wimmer, H. (1985). "John thinks that Mary thinks that…" attribution of second-order beliefs by 5-to-10-year-old children. *Journal of Experimental Child Psychology, 39*(3), 437–471.

Phillips, L. H., Allen, R., Bull, R., Hering, A., Kliegel, M., & Channon, S. (2015). Older adults have difficulty in decoding sarcasm. *Developmental Psychology, 51*(12), 1840.

Phillips, L. H., Slessor, G., Bailey, P. E., & Henry, J. D. (2014). Older adults' perception of social and emotional cues. 9-25.

Pomareda, C., Simkute, A., & Phillips, L. H. (2019). Age-related differences in the ability to decode intentions from non-literal language. *Acta Psychologica, 198*, 102865.

R Core R R Core Team. (2017). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation forStatistical Computing. URL https://www.R-pro ject.org/ (considerations. *Journal of Personality and Social Psychology, 51*(6), 1173.).

Roberts, A., Savundranayagam, M., Orange, J.B. (2017) Non-Alzheimer Dementias. In: Cummings L. (eds) Research in Clinical Pragmatics. Perspectives in Pragmatics, *Philosophy & Psychology*, vol 11. Springer, Cham. https://doi.org/10.1007/978-3-319-47489-2_14.

Rothermich, K., & Pell, M. D. (2015). Introducing RISC: A new video inventory for testing social perception. *PLoS One, 10*(7), Article e0133902.

Ruffman, T., Henry, J. D., Livingstone, V., & Phillips, L. H. (2008). A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. *Neuroscience and Biobehavioral Reviews, 32*(4), 863–881. https://doi.org/10.1016/j.neubiorev.2008.01.001

Satterthwaite, F. E. (1946). An approximate distribution of estimates of variance components. *Biometrics Bulletin, 2*(6), 110–114.

Scheibe, S., Sheppes, G., & Staudinger, U. M. (2015). Distract or reappraise? Age-related differences in emotion-regulation choice. *Emotion, 15*(6), 677.

Seckman, M. A., & Couch, C. J. (1989). Jocularity, sarcasm, and relationships: An empirical study. *Journal of Contemporary Ethnography, 18*(3), 327–344.

Shammi, P., & Stuss, D. T. (2003). The effects of normal aging on humor appreciation. *Journal of the International Neuropsychological Society, 9*(6), 855–863.

Snowden, J. S., Gibbons, Z. C., Blackshaw, A., Doubleday, E., Thompson, J., Craufurd, D., … Neary, D. (2003). Social cognition in frontotemporal dementia and Huntington's disease. *Neuropsychologia, 41*(6), 688–701.

Sperber, D., & Wilson, D. (1981). Irony and the use-mention distinction. *Philosophy, 3*, 143–184.

Sullivan, S., & Ruffman, T. (2004). Emotion recognition deficits in the elderly. *International Journal of Neuroscience, 114*(3), 403–432.

Uekermann, J., Channon, S., & Daum, I. (2006). Humor processing, mentalizing, and executive function in normal aging. *Journal of the International Neuropsychological Society: JINS, 12*(2), 184.

Uekermann, J., Thoma, P., & Daum, I. (2008). Proverb interpretation changes in aging. *Brain and Cognition, 67*(1), 51–57.

West, R., & Covell, E. (2001). Effects of aging on event-related neural activity related to prospective memory. *Neuroreport, 12*(13), 2855–2858.

Yorkston, K. M., Bourgeois, M. S., & Baylor, C. R. (2010). Communication and aging. *Physical Medicine and Rehabilitation Clinics, 21*(2), 309–319.