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Multimodal mate choice: Exploring the effects of sight, sound, and scent on partner choice in a speed-date paradigm

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ABSTRACT

When people meet a potential partner for the first time, they are confronted with multiple sources of information, encompassing different modalities, that they can use to determine whether this partner is suitable for them or not. While visual attractiveness has widely been studied with regard to partner choice, olfactory and auditory cues have received less attention, even though they might influence the attitudes that people have towards their partner. Therefore, in this study, we employed a combination of pre-date multimodal rating tasks followed by speed-date sessions. This offered a naturalistic setup to study partner choice and disentangle the relative effects of a priori attractiveness ratings of sight, scent and sound on date success. Visual attractiveness ratings showed a strong positive correlation with propensity to meet the partner again, while the effects of olfactory and auditory attractiveness were negligible or not robust. Furthermore, we found no robust sex differences in the importance of the three modalities. Our findings underscore the relative importance of visual attractiveness in initial mate choice, but do not corroborate the idea that static pre-date measures of auditory and olfactory attractiveness can predict first date outcomes.

1. Introduction

Choosing a partner is an extremely important decision, not only because a good relationship is one of the main predictors for a happy life (Soons, Liefbroer, & Kalmijn, 2009), but also from an evolutionary perspective. Selecting a suitable partner might result in healthy offspring; whereas, a wrong choice might result in loss of fitness (Buss & Schmitt, 2019). However, humans typically lack explicit knowledge about the quality of potential partners when meeting them for the first time. This raises the question of how people distinguish between preferred and non-preferred mates based on brief interactions (Kurzban & Weeden, 2005). Evolutionary-based theories posit that humans evolved partner preferences for physical traits that are indicative of mate quality, such as facial attractiveness, sound of voice, and olfactory pleasantness (Grammer, Fink, Møller, & Thornhill, 2003). Therefore, humans might initially filter potential partners on the basis of these traits and then only select the suitable individuals (Dixson, 2012; Fisher, 1998). Here, we investigated how different sensory modalities influence this initial filtering by combining a naturalistic speed-dating event with multimodal rating tasks to disentangle the effects of scent, facial attractiveness, and the attractiveness of the voice on dating success.

It is well known that attractive humans experience numerous benefits in human societies. For example, individuals that are considered attractive might receive a more positive evaluation of their personalities, have higher chances of being hired for a position, and tend to go on more dates than less attractive people (Little, Jones, & DeBruine, 2011). Interestingly, visual attractiveness seems to transcend cultural boundaries, as people from different cultures seem to largely agree on attractiveness ratings (Langlois et al., 2000). Not only do people agree on what is attractive, but visual attractiveness is central in human mate choice for both men and women (Buss & Barnes, 1986; Rhodes, 2006). Previous research has shown that facial attractiveness predicts female and male attraction to a partner (Feingold, 1990; Luo & Zhang, 2009), also in speed-date settings (Asendorpf, Penke, & Back, 2011; Sidari et al., 2020). It has been suggested that choosing an attractive partner might help to ensure offspring with good quality, as different aspects of facial attractiveness may indicate optimal health or genetic quality (Rhodes, 2006; but see Foo, Simmons, & Rhodes, 2017). Thus, visual attractiveness is an important part of human mate choice.

Visual input is not the only information humans perceive when

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selecting a mate. On the contrary, recent evidence suggests that attractiveness is multimodal, and voice and scent also influence mate choice decisions (Groyecka et al., 2017). Humans can efficiently extract information about a person's identity and current state from a voice, such as female ovulatory status (Bryant & Haselton, 2009; Puts et al., 2013), emotional state (Belin, Fillion-Bilodeau, & Gosselin, 2008), male physical dominance (Hodges-Simeon, Gaulin, & Puts, 2010; Sell et al., 2010), body size (Wheatley et al., 2014), and age (Skoog Waller, Eriksson, & Sörqvist, 2015). When it comes to voice qualities and voice attractiveness, multiple aspects seem to affect what is considered an attractive voice. For example, women tend to prefer lower-pitch voices (masculine voices), while men prefer higher-pitch voices (feminine voices), and both men and women prefer averaged voices. Importantly, these general preferences do seem to differ between individuals; suggesting that what is an attractive voice for one person, might not be attractive for the other (Pisanski & Feinberg, 2018; Vukovic et al., 2010, 2011). This finding highlights the importance of accounting for individual preferences when examining partner choice. Even though people can identify attractive voices from recordings, vocal attractiveness is also affected by the dynamics during an interaction, such as changes in voice pitch (Pisanski, Oleszkiewicz, Plachetka, Gmiterek, & Reby, 2018) and vocal convergence (Farley, Hughes, & LaFayette, 2013). Thus, whether attractiveness ratings of isolated vocal samples predict date success remains to be examined.

Not only the voice, but also the scent of a potential partner might be used as a cue when it comes to partner choice (Havlíček et al., 2008; Mahmut & Croy, 2019; White & Cunningham, 2017). Importantly, humans use scent to extract an impressive amount of information relevant for mate choice, such as sex, dominance, fertility, health, and genetic compatibility (Groyecka et al., 2017; Lobmaier, Fischbacher, Wirthmüller, & Knoch, 2018; Roberts, Gosling, Carter, & Petrie, 2008). Interestingly, smell might be more important for women than for men (Havlíček et al., 2008). Previous research on olfactory preferences of men have mainly focused on genetic compatibility (e.g., Roberts et al., 2008) and ovulatory shift effects (e.g., Lobmaier et al., 2018), while the contribution of olfactory attractiveness in male mate choice has remained relatively unexplored. Altogether, these findings suggest that incorporating vocal and olfactory cues of attractiveness might explain a substantial amount of variance in mate choice.

Despite the plethora of studies on attractiveness and partner choice, the question of how the different modalities of attractiveness relate to one another remains equivocal. From an adaptive point of view, the different modalities can either convey the same information (*back-up cue hypothesis*), or convey different information (*multiple message hypothesis)* about an individual (Candolin, 2003). Thus, according to the *back-up cue hypothesis,* multimodal cues might all reflect the same underlying mate quality, which would result in a more accurate assessment of mate quality. Alternatively, the *multiple message hypothesis* assumes that multimodal cues might each reflect different aspects of mate quality. Taken together, these cues reflect overall mate quality; however, each multimodal cue reflects a different *component* of this quality (Candolin, 2003; Johnstone, 1997). For humans, multiple studies have suggested that different modalities covary in signaling underlying mate quality. For example, both vocal and facial characteristics correlate in women (Collins & Missing, 2003), and may be used to assess hormonal status (Feinberg, 2008), and ratings of facial attractiveness and olfactory attractiveness concord in both men and women (Cornwell et al., 2004). This suggests that the different modalities might indeed reflect the same qualities in humans.

Traditionally, studies have investigated the role of scent, sight and sound by means of isolated experiments in which participants rated multiple static samples for attractiveness and long-term partner suitability. Consecutively, these ratings are often linked to traits of the sampled individual, such as masculinity and feminity (e.g., Collins & Missing, 2003; Cornwell et al., 2004; Little, Connely, Feinberg, Jones, & Roberts, 2011). However, it has not yet been established how these individual ratings relate to real-life partner choice. In our study, we combined these widely-used multimodal attractiveness ratings of static stimuli with a speed-date paradigm. Speed-dates are a useful tool to study social decision making, as they allow for experimental control, while at the same time offering high ecological validity (Finkel, Eastwick, & Matthews, 2007). Thus, by combining pre-date multimodal rating tasks with consecutive speed-date outcomes, the current study explores whether pre-date attractiveness ratings of the different modalities correlate with willingness to meet again after a speed-date. Our study especially explores three main topics, namely (i) how do pre-date attractiveness ratings of different modalities relate to each other, (ii) is attraction indeed multimodal, and (iii) do men and women differ when it comes to the importance of the differen modalities?

2. Methods

2.1. Participants

Eighty participants were recruited through online advertisement and flyering at the university buildings for a scientific speed-dating event in Leiden, The Netherlands. Seventy ($N = 70$) attended the experimental session (35 women, $M_{age} = 22.03$, $SD = 2.14$; men: $M_{age} = 22.49$, $SD = 1.97$). Twenty-two women used hormonal contraceptives. In line with the inclusion criteria, all participants reported that they were between 18 and 26 years old, heterosexual, single, Dutch-speaking, and not under treatment for psychiatric disorders. Furthermore, all participants reported normal or corrected-to-normal vision and normal color vision, as well as normal hearing acuity. Three participants (1 woman) dropped out before the speed-dating part of the study; resulting in a final sample of 67 participants and 277 speed-dates. All participants provided informed consent as according to the declaration of Helsinki. Participants were not compensated for their participation, but received a ticket to Apenheul Primate Park (Apeldoorn, the Netherlands) to thank them for their participation. The procedure and methods were approved by the Leiden University Ethics Committee (CEP: 2020-02-20-M.E. Kret-V1–2169).

2.2. Procedure

The experiment (pre-registered using the AsPredicted database, reference number: #36394) took place on the 28th of February and 1st of March 2020 in Leiden, The Netherlands. In the 4 weeks before the experiment, participants signed up via an online Qualtrics form (Qualtrics, Provo, UT), where they selected a specific time to participate in the experiment (i.e. selected their group). Each group consisted of a maximum of 10 men and 10 women. Participants were instructed that prior to their arrival they avoid wearing heavy make-up, strong-smelling products (e.g., perfume and deodorant), and provocative clothing.

Upon arrival to the experimental session, men and women were seated in different rooms and were asked to provide informed consent, and fill in questionnaires regarding background information (e.g., education, use of dating apps) and trait sexual desire (Elaut et al., 2010; Spector, Carey, & Steinberg, 1996). After participants completed the questionnaires, a researcher took a standardized portrait picture separately for each participant using a Canon EOS 40D camera set at portrait mode, with a EF 28-135 mm f/3.5–5.6 IS USM lens. The photographer was located 1 m from the participant, and zoomed in so that a slight empty space was present around the face of the participant. For this picture, participants were asked to pull their hair back, remove their glasses, remove large pieces of jewelry, and display a neutral facial expression. The photographs were not edited further.

The audio stimuli were recorded in a separate sound-proof room. A researcher recorded audio stimuli separately for each participant. Participants were asked to read out loud the Dutch equivalent of the RAINBOW passage (Van Lierde, Wuyts, De Bodt, & Van Cauwenberge, 2001) using a Shure MV5 microphone set at flat mode (i.e., no

equalization or compression) and Audacity® (sample rate:44.1 kHz). Participants were instructed to sit approximately 30 cm away from the microphone, and to speak with normal pace, volume, and tone. If the participant made a mistake while reading the text, the recording was repeated from the start. Stimulus collection occurred in parallel for men and women, and lasted approximately 1 h.

In addition, each participant brought a worn t-shirt which was used as olfactory stimulus. To standardize the preparation of the olfactory stimuli, we asked participants to wear the t-shirt during the night before the experiment, and put it in a closed plastic bag in the morning. Furthermore, we asked them to follow specific guidelines (Roberts et al., 2008) before and during wearing the t-shirt: a) not use perfumed products; b) avoid excessive consumption of alcohol and tobacco; c) not consume spicy foods; d) refrain from sexual activity; e) sleep alone.

Following stimulus collection, participants performed six cognitive tasks, three of which were the rating tasks for sight, sound, and scent (see below). The task-related section of the experiment lasted approximately 1 h. Thereafter, all participants were asked to proceed to the speed-date room, where they had a maximum of 10 speed-dates. The speed-dating phase of the study lasted for a maximum of 1 h. After the end of the experiment, participants were thanked for their participation, received a zoo ticket, and were debriefed.

2.3. Rating tasks

In all rating tasks, participants rated the stimuli on a 1–7 scale. First, they answered the question "How attractive do you find this person's face/voice/scent?". Second, they answered the question "How suitable do you find a person with these looks/this voice/this scent as a long-term partner?". For all three modalities, the rating tasks were presented on a desktop computer via *E*-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA). Participants could rate the stimuli by using numeric keys 1 to 7. Stimulus order was randomized for all participants. In addition, the task order was randomized, so that not all participants rated the different modalities in the same order.

To measure facial attractiveness and vocal attractiveness, participants rated 10 opposite-sex pictures and 10 opposite-sex audio fragments on attractiveness and long-term partner suitability. The stimulus set consisted of the stimuli gathered from the 10 opposite-sex participants in the same timeslot. If the number of opposite-sex participants was lower than 10, extra stimuli of participants from another timeslot were added to make sure that the number of trials was the same for all participants. The pictures were presented for 3 s on a computer monitor, while presentation duration of the audio recordings was equivalent to their duration (±20 s). Participants used a Logitech H340 USB Headset to listen to the audio recordings.

To measure olfactory attractiveness, we used the t-shirts that participants prepared at home. After arrival, each t-shirt was placed in a glass jar, that was numbered 1–10 (see also Roberts et al., 2008). We wrapped all jars in black paper, so that participants could not see the visual features of the t-shirt. In each trial of the experiment, a random number between 1 and 10 appeared on the screen. A researcher, wearing surgical gloves, brought the corresponding jar to the participant and allowed the participant to smell the t-shirt and next rate the attractiveness of the scent (see above). However, there were two important differences compared to the visual and vocal rating task. First, participants could indicate that the scent was not strong enough to answer the question(s) by pressing the *0* keyboard key, to control for samples with extremely low intensity. Second, if the number of opposite-sex participants in a group was lower than 10, the remaining jars would stay empty. So the number of trials between groups and sexes could slightly differ for the olfactory task.

2.4. Speed-dates

In the speed-date room, men and women were seated 2 by 2 at opposite sides of a table. We made video recordings of both participants during each date, the content of which will not be further discussed in the present paper. Barriers were placed on the table to avoid that participants would interact before the date started. At the start of each date, participants were asked to rotate the barriers in front of them by 90 degrees, so that each table was divided into two "dating booths". Thereafter, the start of the date was indicated by a ringing bell. After 4 min, the participants were asked to turn the barriers again and indicate a) how attractive they found their partner; b) how attractive they considered them as a long-term mate; c) whether they would be interested in going on another date with them; d) whether their partner would like to go on another date with them; e) whether they knew each other from before. Answers on questions a, b, and c were very strongly correlated (Supplementary Table 1 & 2). Participants were given approximately 1 min to fill in the scorecard. After each date, men moved one seat to the left.

In each group, the number of speed-date rounds depended on the number of participants in each group per sex, with a maximum of 10 rounds. In addition, if the number of men and women was not equal, the overrepresented sex had one or multiple rounds without a speed-date. In total, the experiment consisted of 277 speed-dates, thus resulting in 554 filled-in scorecards.

2.5. Data processing

Because of technical issues, in the second female group ($N = 8$) we could not collect data for the vocal and visual rating task, and thus had to exclude them from further analysis. Second, one of the auditory stimuli that was used in the third female group did not match with the male in that group. Therefore, all data for the male whose auditory stimulus was missing was excluded from analysis. Third, one male in the second group did not complete the visual rating task. Fourth, we excluded all rows in which the participant had scored the olfactory rating with a 0, as this was an indication that the participant could not make a choice based on the sample.

After excluding the above-mentioned data, we first tested how strongly the attractiveness ratings correlated with long-term partner suitability ratings using Bayesian ordinal regressions (see Data Analysis). Because the two questions were always asked together, and in the same order, we suspected a carry-over effect, resulting in almost identical ratings for attractiveness and long-term partner suitability. This was indeed the case for all three modalities (Supplementary Table 3–6). Because of the strong degree of correlation, we used only the attractiveness ratings in our further statistical analyses. We chose attractiveness ratings over long-term partner ratings because the former are more straightforward and align better with the relatively short-term context of a speed-date event. The full dataset based on the attractiveness ratings of all three modalities and speed-date outcomes included 457 complete cases after exclusion of data as described above. For the independent models, we used all complete cases of the specific modality (visual: 482, auditory: 481, olfactory: 533; see Table 2, Supplementary Table 7).

2.6. Data analysis

To analyse the data, we used Bayesian ordinal regression to test how the different modalities were correlated with each other, and Bayesian mixed models to explore whether attractiveness ratings were associated with speed-date outcome. All Bayesian models were created in the Stan computational framework and accessed using the **brms** package (Bürkner, 2017, 2018), version 2.13.5. In all analyses we centered ratings at 4, because this was the middle option. This was done to ease setting priors on the intercept. All models were run with 4 chains and 5000 iterations, of which 1000 were warmup iterations. We checked model convergence by inspecting the trace plots, histograms of the posteriors, Gelman-Rubin diagnostics, and autocorrelation between iterations (Depaoli & van de Schoot, 2017). We found no divergences or

excessive autocorrelation.

For the ordinal regressions, which allow the dependent variable to be of the ordinal type (Bürkner & Vuorre, 2019), we specified six models with a cumulative distribution, consisting of the attractiveness ratings for one modality as dependent variables, and attractiveness ratings of another modality as predictor. We added random intercepts for rater and rated individual, and allowed the slope of the predictor to vary by rater. Furthermore, we retained the default priors for the error terms and thresholds, and set conservative Gaussian priors with a mean of 0 and SD of 0.5 for the predictor.

To test the relationship between multimodal attractiveness and speed-date outcome, we used Bayesian mixed models with a Bernoulli distribution, with willingness to meet again (yes/no) as response variable. First, we conducted a partial correlation analysis, which contained visual, auditory and olfactory attractiveness each interacting with sex as predictors. Second, we used three independent models with either visual, auditory or olfactory attractiveness as predictor, interacting with sex. This allowed us to see how strong the correlations were per modality when not controlling for the other two modalities. Also, it allowed for a slightly smaller sample size per modality, because we there were more complete cases. We added random intercepts for participant and dating partner, and allowed slopes for the attractiveness ratings to vary by participant. With regard to priors, we set a conservative Gaussian prior with a mean of 0 and SD of 1 for the intercept. For the predictors, we used conservative Gaussian priors with a mean of 0 and SD of 0.5. For the error terms, we set half-Cauchy priors with a scale of 1.

We report multiple quantitative measures to summarize the posterior distribution. First, we report the median Odds Ratio (*MdnOR*) and median absolute deviation of the Odds Ratio (MAD) of the estimate. Second, we report a 89% credible interval of the Odds Ratio (89% CrI). We have chosen 89% instead of the conventional 95% to reduce the likelihood that our results are interpreted as strict hypothesis tests (McElreath, 2018). Instead, the goal of the credible intervals is to communicate the shape of the posterior distributions. Third, we report the probability of direction (*pd*), i.e. the probability of a parameter being strictly positive or negative, which varies between 50% and 100% (Makowski, Ben-Shachar, Chen, & Lüdecke, 2019). Fourth, we report an approximation of Cohen's *d* (Borenstein, Hedges, Higgins, & Rothstein, 2009).

2.7. Data availability statement

The data associated with this research are available at Dataverse via https://doi.org/10.34894/5VLTJ0.

3. Results

3.1. Correlation between modalities

We first explored whether the attractiveness ratings in the different modalities were correlated, using Bayesian ordinal regressions (Table 1, Supplementary Table 8–10). We found that all modalities were slightly positively correlated. However, this relationship became most apparent for the correlations between visual and auditory, and visual and olfactory attractiveness, while the correlation between auditory and olfactory attractiveness was not as robust. Importantly, even for the former two findings, effect sizes were relatively small, indicating that the correlation between the modalities is not strong. Furthermore, estimates were very similar for men and women.

3.2. Multimodal attractiveness and date outcome

3.2.1. Partial effects

To determine the relationship between multimodal attractiveness ratings and date outcome, we used a Bayesian mixed model with a Bernoulli distribution (Supplementary Table 11; Fig. 1). We found a robust positive association between visual attractiveness rating and date outcome, meaning that participants were more likely to indicate they wanted to go out again with individuals that they had rated as visually attractive (Fig. 1A). This pattern was apparent for both male (*MdnOR* = 3.09 [0.62], 89% CrI [2.31; 4.40], *pd* = 1.00, *d* = 0.62 [0.11]) and female (*MdnOR* = 2.25 [0.40], 89% CrI [1.71; 3.06], *pd* = 1.00, *d* = 0.45 [0.10]) participants. While the effect was slightly stronger for males, the difference between males and females was not robust (*MdnOR* = 1.38 [0.32], 89% CrI [0.96; 2.03], *pd* = 0.92, *d* = 0.18 [0.13]).

With regard to auditory attractiveness (Fig. 1B), we found a small positive association for males, suggesting that men were more likely to want to go on another date with women whose voices they rated as attractive (*MdnOR* = 1.31 [0.22], 89% CrI [0.99; 1.72], *pd* = 0.94, *d* = 0.15 [0.10]). For females, on the other hand, no robust pattern emerged (*MdnOR* = 1.17 [0.20], 89% CrI [0.89; 1.55], *pd* = 0.82, *d* = 0.08 [0.09]). In addition, we found no robust sex difference in the importance of auditory attractiveness (*MdnOR* = 1.12 [0.25], 89% CrI [0.78; 1.61] *pd* = 0.69, *d* = 0.06 [0.12]).

For olfactory attractiveness, however, we found an opposite pattern (Fig. 1C). For males, we found no clear directional effect of olfactory attractiveness on date outcome (*MdnOR* = 0.93 [0.14], 89% CrI [0.73; 1.18], *pd* = 0.69, *d* = 0.04 [0.08]), while we found a robust but small negative association for females (*MdnOR* = 0.73 [0.11], 89% CrI [0.57; 0.92], *pd* = 0.99, *d* = 0.17 [0.18]). This indicates that women were slightly less likely to want to meet again with men they rated as smelling attractive. While the effect for women was stronger than for men, the sex difference was not robust (*MdnOR* = 1.27 [0.25], 89% CrI [0.93; 1.75], *pd* = 0.89, *d* = 0.13 [0.11]).

3.2.2. Independent effects

Because some of the ratings showed some correlation between modalities, and visual attractiveness was such a strong predictor in the partial effects model, we also explored the correlation between attractiveness rating and date outcome using independent models per

Table 1
Estimates and effect size measures for the concordance in attractiveness ratings between modalities. All estimates are based on ordinal regression models (see Supplementary Table 8–10).

Dependent	Predictor	Rater sex	*Median OR*	*CrI 89%*	*pd*	*d*	*N*
Visual	Auditory	Female	1.25 [0.15]	1.04; 1.52	0.97	0.12 [0.07]	473
Visual	Auditory	Male	1.27 [0.13]	1.08; 1.51	0.99	0.13 [0.06]	
Auditory	Visual	Female	1.30 [0.15]	1.09; 1.56	0.99	0.15 [0.06]	
Auditory	Visual	Male	1.38 [0.16]	1.15; 1.66	1.00	0.18 [0.06]	
Visual	Olfactory	Female	1.21 [0.12]	1.03; 1.42	0.97	0.10 [0.06]	465
Visual	Olfactory	Male	1.20 [0.12]	1.02; 1.40	0.96	0.10 [0.05]	
Olfactory	Visual	Female	1.24 [0.13]	1.04; 1.47	0.97	0.12 [0.06]	
Olfactory	Visual	Male	1.22 [0.13]	1.03; 1.46	0.97	0.11 [0.06]	
Auditory	Olfactory	Female	1.15 [0.11]	0.98; 1.34	0.92	0.08 [0.05]	465
Auditory	Olfactory	Male	1.13 [0.11]	0.97; 1.31	0.90	0.07 [0.05]	
Olfactory	AUDITORY	Female	1.20 [0.13]	1.00; 1.44	0.95	0.10 [0.06]	
Olfactory	Auditory	Male	1.12 [0.11]	0.96; 1.31	0.88	0.06 [0.05]	

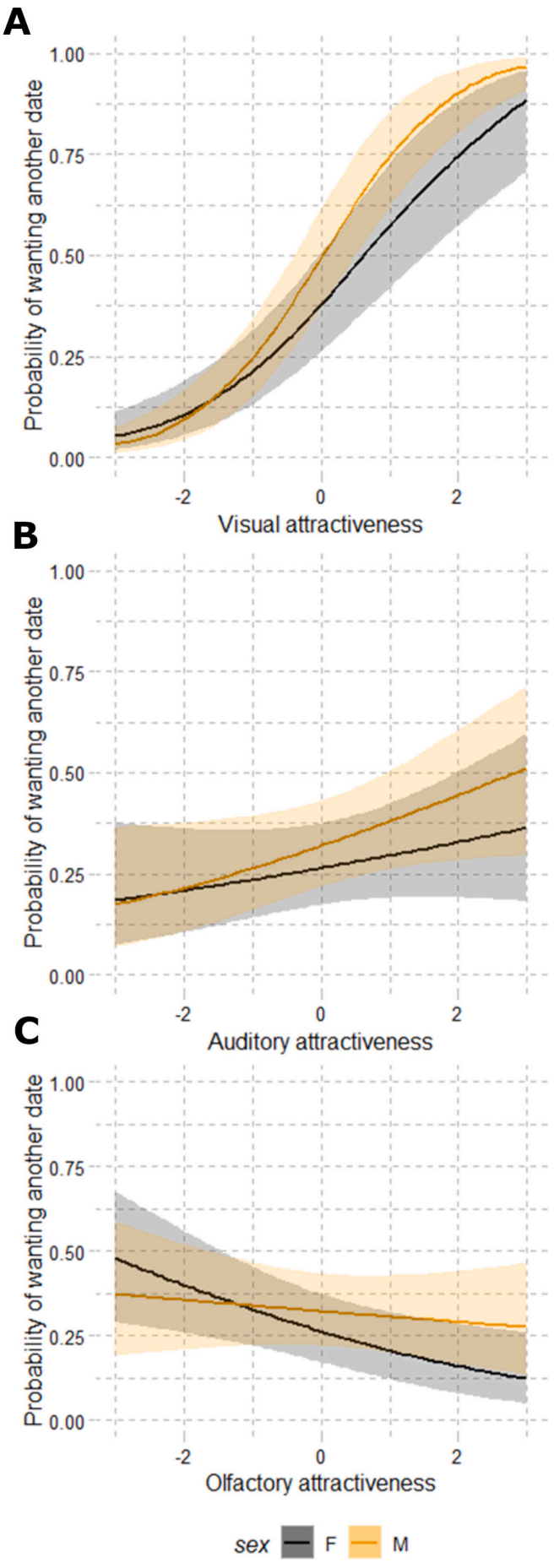

Fig. 1. The relationship between visual (A), auditory (B), and olfactory (C) attractiveness ratings (centered) and probability of wanting another date, for both male raters and female raters. Values are conditioned on the mean for the other predictors. Shaded areas show 89% Credible Intervals.

Table 2
Estimates and effect size measures for independent logistic regressions, separately testing the effect of attractiveness in each modality on propensity to date again (see Supplementary Table 7).

Modality	Rater sex	*Median OR*	*CrI 89%*	*pd*	*d*	*N*
Visual	Female	2.01 [0.31]	1.59; 2.61	1.00	0.39 [0.08]	482
Visual	Male	2.91 [0.50]	2.24; 3.92	1.00	0.59 [0.10]	
Visual	Interaction	1.45 [0.30]	1.04; 2.05	0.96	0.20 [0.12]	
Auditory	Female	1.26 [0.20]	0.98; 1.65	0.93	0.13 [0.09]	481
Auditory	Male	1.30 [0.20]	1.02; 1.67	0.96	0.14 [0.08]	
Auditory	Interaction	1.04 [0.21]	0.74; 1.44	0.55	0.02 [0.12]	
Olfactory	Female	0.82 [0.10]	0.66; 0.99	0.95	0.11 [0.07]	533
Olfactory	Male	1.08 [0.14]	0.88; 1.34	0.73	0.04 [0.07]	
Olfactory	Interaction	1.33 [0.23]	1.01; 1.76	0.95	0.16 [0.10]	

modality (Table 2; Supplementary Table 7). We found that the relationship between auditory attractiveness and date outcome became slightly more apparent in the independent models for females. Furthermore, we found more robust sex differences in the visual context (i.e., visual attractiveness was more strongly correlated with date outcome for males than for females) and the olfactory context (i.e., a small negative correlation between olfactory attractiveness and date outcome for females, and no clear pattern for males). However, the independent models still indicated that visual attractiveness showed a strong positive correlation with date outcome for both men and women.

4. Discussion

Choosing a romantic partner is an important life decision. Previous research has mainly focused on the role of physical attractiveness during early stages of partner choice (Asendorpf et al., 2011; Kurzban & Weeden, 2005; Sidari et al., 2020). However, recent evidence reveals that attractiveness is multimodal, further involving scent and sound (Groyecka et al., 2017). Therefore, here, we examined the effect of multimodal attractiveness ratings of static samples in an ecologically valid speed-date setting (Finkel et al., 2007) and asked participants to indicate whether they would like to meet their dating partner again. To our knowledge, this is the first study that examines the effect of sight, sound and scent on speed-date outcomes. Our results are threefold. First, we show that there were only low levels of covariance in the different modalities of attractiveness. Second, using a partial model and independent models, we show that pre-date visual attractiveness ratings correlate strongly with propensity to meet again, while no strong effects were found for vocal and olfactory attractiveness. Third, in the partial model we found no robust sex differences in the importance of the different modalities. In the independent models, however, we did find robust sex differences for the effects of visual and olfactory attractiveness. Here, we discuss these findings and further address possible limitations of our study.

In the current study we observed that visual attractiveness correlated positively with auditory attractiveness and olfactory attractiveness, respectively. This finding is in line with the *back-up cue hypothesis* (Candolin, 2003; Johnstone, 1997). However, it is important to note that

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the effect sizes were very small when compared to previous studies (Collins & Missing, 2003; Cornwell et al., 2004), and it is therefore questionable whether such low correlations have any practical relevance. In addition, we did not find clear differences between sexes, while some of the previous studies only described such concordance of multimodal attractiveness ratings in a specific sex (e.g., Collins & Missing, 2003). Larger studies may be better suited to detect such nuances in future work.

Our most prominent finding is that, from all three modalities, facial attractiveness showed the strongest correlation with willingness to date again across both genders. This is in line with previous findings from speed-date paradigms (Asendorpf et al., 2011; Luo & Zhang, 2009), and experimental paradigms incorporating multimodal attractiveness ratings (Foster, 2008). This finding is not surprising, given that humans are extremely visually-oriented beings, rendering sight the most conspicuous source of information in mate choice (Krupp, 2008). Thus, our results corroborate the relative importance of facial attractiveness compared to scent and sound during initial phases of partner selection. Indeed, in a busy public place, such as a bar or a speed-dating event for that matter, visual information is the most apparent and reliable cue upon first acquaintance, because auditory cues might be distorted by noise and olfactory cues will be difficult to perceive in isolation (Thomas-Danguin et al., 2014), given the fact that mixing with other people's odour might obfuscate individual olfactory cues.

In line with this notion, we found little evidence to support the multimodal nature of attractiveness during speed-dates. Auditory attractiveness seemed to slightly influence partner choice decisions in men: they were more likely to indicate their willingness to go another date if they rated their female partner's voice as attractive. However, the effect was small, especially when compared to the effect that visual attractiveness had on male partner choice decisions. For women, no clear effect of auditory attractiveness on their partner choice decisions was observed in the partial model, although the independent model showed a similar pattern for both men and women. These findings are somewhat consistent with previous research (Asendorpf et al., 2011), that found a smaller effect of vocal attractiveness than visual attractiveness, although the effect of vocal attractiveness was significant. It is important to note, though, that Asendorpf et al. (2011) obtained visual and auditory attractiveness ratings from an independent group of raters, while we used individual attractiveness ratings to predict dating outcome. Therefore, it is not clear whether these findings are directly comparable. However, the fact that a study using independent raters finds a similar strong effect of visual attractiveness on date outcome shows how important facial attractiveness is, and at the same time suggests it is unlikely that potential demand characteristics underlie our main result.

Furthermore, the effect of auditory attractiveness on dating outcomes might be obfuscated by voice modulation and interpersonal dynamics during speed-dates. People modulate the pitch of their voice when addressing a desirable partner (Fraccaro et al., 2011; Leongómez et al., 2014; Pisanski et al., 2018). In addition, the presence and sound of other people, and a camera recording the interaction, might have further affected the mental states of the participants and, consequently, their voices. Therefore, it is likely that participant's spoke differently (e.g., different pitch) during the audio recordings and the actual dates, leading to the discrepancies in perception of the recorded voice and the voice that was heard on the date on the rater's end. Thus, using an isolated rating task for voices might have slightly obscured the importance of voice during the actual dates. Future research should compare how isolated measures of vocal attractiveness relate to vocal attractiveness in an explicitly social context such as a date.

We found a small effect of olfactory attractiveness on willingness to date again for women, but not for men. Interestingly, the relationship that we found for women was negative: they were less likely to want to go on another date with men whose smell they rated as attractive. This direction of the effect is surprising given previous evidence suggesting that scent plays an important role in mate selection for women (Havlíček et al., 2008). It is unclear why this effect might have occurred. One possible explanation is a methodological one: the olfactory samples employed in the present study should be perceived as indicators of diplomatic body odour (Gaby & Zayas, 2017). Diplomatic body odour samples might be more ecologically valid than natural body odour samples, as odours are heavily affected by the use of hygiene products and personal habits in real life, which may interfere with olfactory cues for mate choice (Allen, Cobey, Havlíček, & Roberts, 2016; Gaby & Zayas, 2017; Sorokowska, Sorokowski, & Havlíček, 2016). With regard to the negative correlation we found, it can theoretically be possible that men who know they have a strong body odour used extra hygiene products when wearing the t-shirt, even though they were instructed not to. This would then result in high attractiveness ratings for odour, while the actual smell perceived on the date would be unpleasant. Note that this explanation does assume that women actually perceived the natural odour during the date. Because we have no compliance data for the t-shirt preparation, we can unfortunately not exclude this explanation. Such potential dicrepancies between different types of body odour highlight the difficulties of studying the effects of olfaction on human mate choice (Ferdenzi, Richard Ortegón, Delplanque, Baldovini, & Bensafi, 2020), and future studies could consider incorporating both natural and diplomatic samples.

Importantly, some important questions about multimodal attractiveness and initial attraction remain. For example, a question that we have not investigated is how cross-modal interactions shape attraction. Given our sample is relatively small, we could not examine such complex relationships. Nonetheless, investigating such dynamics might be vital to grasp the complex dynamics of multimodal attractiveness (Groyecka et al., 2017). For example, having an attractive voice and an attractive face might especially increase dating success, or unattractiveness on one modality might reduce the positive effect of the other modality (Demattè, Österbauer, & Spence, 2007). We suggest that large-scale studies using a similar design to our studies are necessary to further elucidate these complex interactions. Another example concerns the context-dependent importance of the different modalities. Visual and vocal attractiveness might be especially important during first interactions in which close contact is rare. Olfactory attractiveness, however, may be important during more advanced stages of the relationship (Groyecka et al., 2017), when close contact is more common, or during first interactions with close physical contact. Altogether, investigating cross-modality interactions and context-dependence are essential to understand how multimodal attractiveness shapes initial attraction.

In conclusion, our results corroborate the importance of visual attractiveness in early stages of mate choice. At the same time, the static attractiveness ratings for auditory and olfactory attractiveness did not substantially predict date outcome. This suggests that especially visual attractiveness is relatively important during speed-dates, while auditory and olfactory attractiveness are less important. Nonetheless, these modalities might come into play in other stages of the developing relationship or in other contexts. Furthermore, attractiveness of voice and smell may be more strongly influenced by dynamics during an interaction, rendering static attractiveness ratings to be less predictive. Altogether, our findings illustrate that the coupling of multimodal rating tasks and speed-date paradigms is a fruitful method of studying multimodal human mate choice. Applying such methods with large-scale samples allows for disentangling the effects of different factors on date outcome, and could further aid in understanding how human mate choice is affected by sight, sound, and scent.

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Declaration of Competing Interest

The current version of the manuscript was approved by all authors. The authors declare no conflict of interest.

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Appendix A. Supplementary data

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