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Autistic adults display different verbal behavior only in mixed-neurotype interactions: Evidence from a referential communication task

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Abstract

Recent accounts of social difficulties in autism suggest that autistic and non-autistic individuals mutually misunderstand each other. This assumption aligns with findings that mixed-neurotype interactions are less efficient than same-neurotype interactions. However, it remains unclear whether different outcomes between mixed- and same-neurotype interactions are due to contact with a different neurotype or to inherently different communication styles, specific to each neurotype. A total of 134 adult participants were divided into three same-sex dyad types: 23 autistic dyads, 23 non-autistic dyads, and 21 mixed-neurotype dyads. Participants were unaware of their partner's neurotype. Dyads completed an online referential communication task where a "Director" guides a "Matcher" to rearrange abstract images, using both written (chat) and oral (microphone, no video) communication modes. Interaction outcome measures were task duration and verbosity of the Director. Across both communication modes, non-autistic dyads completed the task faster than autistic and mixed dyads, indicating that dyads with at least one autistic partner were generally slower. Notably, in mixed dyads, autistic Directors were more verbose than non-autistic Directors across both communication modes. These results, in conjunction with partners' unawareness of each other's neurotype, suggest that even in the absence of non-verbal cues neurotype mismatch triggers autistic adults to display different verbal behavior.

Lay abstract

Recent research shows that in conversations, both participants influence the outcome. More specifically, conversations do not go as smoothly when autistic and non-autistic people talk together compared to when people of the same neurotype (either all autistic or all non-autistic) talk to each other. In studies finding a "same-neurotype communicative advantage", interaction partners knew about each other's neurotype. Because of this methodological choice, it is unclear whether mixed-neurotype interactions go less smoothly because participants knew they were interacting with a different neurotype or because each neurotype really has a distinct communication style. In our study, 134 adults were grouped into same-sex pairs: 23 autistic, 23 non-autistic, and 21 mixed-neurotype pairs. The pairs did not know if the other person was autistic or not. They completed an online task where the "Director" instructs the "Matcher" to reorder abstract pictures. Pairs did this task in two ways: by typing in a live chat and by speaking into a microphone without video. The study looked at how long the task took and how much the Director talked/wrote. Results showed that non-autistic pairs were faster to complete the task than autistic pairs and mixed pairs, meaning pairs with at least one autistic person were slower in general to complete the task. Interestingly, in mixed pairs, only autistic Directors produced more words than non-autistic Directors, in both typing and speaking. These findings suggest that even without knowing about their partner's neurotype and seeing/hearing their partner, autistic adults communicate differently when they interact with a non-autistic person.

Keywords

neurotype (mis)match, oral versus written language, referential communication

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Introduction

Differences and/or difficulties in social interactions and communication are some of the core features of autism (American Psychiatry Association, 2013) that significantly impact the everyday lives of autistic people (Black et al., 2020; Cummins et al., 2020; Goddard & Cook, 2022). Traditionally, these difficulties have been linked to autistic individuals' atypicalities in social cognition, such as challenges in perspective-taking and interaction management (Davis & Crompton, 2021). However, recent research suggests that social difficulties in autism are not only intrinsic to autistic individuals but are also relational (Bolis et al., 2018; Davis & Crompton, 2021; Milton, 2012) because autistic and non-autistic individuals have different communication and socio-cognitive styles (Milton et al., 2020; Russell et al., 2019). As such, it is a "double problem" that affects both individuals involved in the interaction (Milton, 2012).

This view underlines the reciprocal role of each interaction partner and is supported by a growing body of empirical evidence. For example, autistic people have self-reported that they prefer interactions with other autistic people rather than with non-autistic people (Cummins et al., 2020), and find interactions with other autistic people more comfortable and less tiring than interactions with non-autistic people (Crompton, Hallett, et al., 2020). Likewise, studies on first impressions have shown that non-autistic individuals form more favorable impressions of other non-autistic individuals (e.g. less awkward, more attractive), and report more interest in pursuing interactions with them than with autistic individuals (Morrison et al., 2020; Sasson et al., 2017; Sasson & Morrison, 2019).

A recent study using the "Telephone Game" paradigm with autistic, non-autistic, and mixed-neurotype pairs showed that mixed-neurotype pairs had lower information transfer accuracy and reported rapport compared to same-neurotype pairs (Crompton, Ropar, et al., 2020). Based on the data collected by Crompton, Ropar, et al. (2020), Rifai et al. (2022) found that there were less mutual gaze and backchanneling (i.e. linguistic cues like *mhm* or *ok* addressed to the speaker to signal attentive engagement and understanding) in mixed-neurotype pairs than in non-autistic pairs, and this was associated with lower reported rapport in mixed-neurotype compared to non-autistic pairs. Interestingly, while there was also less backchanneling in autistic pairs, this was not associated with lower reported rapport. Based on this evidence, lower interaction success in mixed-neurotype interactions has been linked to mismatches between the communication styles (use of verbal and non-verbal cues) of autistic and non-autistic individuals, often leading to mutual misunderstandings (Davis & Crompton, 2021).

However, a critical methodological aspect of the studies that found a same-neurotype (autistic-autistic) communicative advantage is that participants were aware of their partner's diagnosis. Hence, it remains unclear whether differences in information transfer between same-neurotype and mixed-neurotype interactions were due to this awareness or to inherent differences in communication styles. Autistic individuals are often hesitant to share their diagnosis due to the judgment, discrimination, and stigma they face after disclosing it (Thompson-Hodgetts et al., 2020). Many also report that revealing their diagnosis changes how others perceive them (Thompson-Hodgetts et al., 2020). To avoid stigmatization and discrimination, autistic participants may adjust their communication style or camouflage/mask certain communicative behaviors if they know their interlocutor is aware of their diagnosis, and if they are aware of their interlocutor's diagnostic status. Likewise, when non-autistic individuals are aware of their partner's autism diagnosis, they may adjust their behavior based on preconceptions or stereotypes about autistic social interaction, further complicating the communication dynamics. Therefore, in this study, we used a "double-blind protocol" to examine the influence of neurotype matching on interaction outcomes without disclosing the diagnosis. This approach allowed us to observe more natural and spontaneous communicative behaviors of both autistic and non-autistic participants.

Another crucial methodological aspect of Crompton, Ropar, et al. (2020) and Rifai et al. (2022) is that the verbal output obtained resembles more a monological narrative than a dialogue: One participant narrates a story to another, who then passes it on to the next person, and so on. As such, it is still unclear how same- and mixed-neurotype pairs share information in a more collaborative task that mirrors real-life interactions and involves the creation and negotiation of meaning. A referential communication task exemplifies such a situation and was used in the current study.

Referential communication tasks, such as the Director task used in this study, are key for studying mutual understanding between conversation partners. The primary objective of this type of task is to make communication partners (a Director and a Matcher) collaborate and create a common understanding of abstract images (such as Image 1 below). The Director and Matcher typically have the same set of abstract images but in different orders. The Director describes the images in the order they see them so that the Matcher can rearrange their images in the same order (see Methods for more detailed information about the task). The Matcher gives feedback on the clarity of these descriptions. Once they agree on a description, the Director can refer to the images in subsequent rounds with a shorter phrase or a single word. This process reduces the number of words and time needed for the task and increases the use of nonce referential labels over time (Arbuckle et al., 2000; Hupet et al., 1993). For example, the Director might initially describe Image 1 as "a strange sign with a triangle at the bottom and a sort of C at the top." As the task progresses and mutual understanding is achieved, the Director might use shorter descriptions for the image, such as "C with line," in the final round.

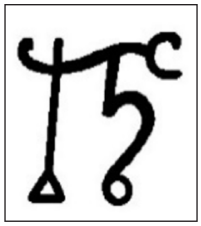

Image 1. Abstract image (taken from Arnold et al., 2007; Yoon & Brown-Schmidt, 2018).

Therefore, referential communication tasks can provide quantitative measures of communication success (i.e. achieving mutual understanding), particularly in terms of word count and round duration. While the Director typically drives the conversation and tends to speak more, both partners are free to discuss the images. This interactive nature allows conversations to extend beyond simple image descriptions, including opportunities for small talk as participants navigate the task together. Thus, these tasks enable us to analyze participants' verbal behaviors in accomplishing the task's goal as well as managing the interaction flow. In this study, we also examined the impact of neurotype mismatch on discussion topics (image description vs small talk).

To date, communicative behaviors in same- and mixed-neurotype interactions have mostly been investigated in face-to-face interactions (Crompton, Ropar, et al., 2020; Georgescu et al., 2020; Morrison et al., 2020; Rifai et al., 2022; but see Wadge et al., 2019), leaving other modes of communication unexplored. However, autistic adults have expressed a preference for written computer-mediated interactions (such as emails and live chats) over face-to-face interactions, as these reduce social and time pressure and the need to interpret body language (Benford & Standen, 2009; Howard & Sedgewick, 2021). Written communication allows autistic individuals time to process what is being said and to formulate their responses. In addition, it removes the expectation of immediate replies (even in live chats), which can alleviate anxiety (Howard & Sedgewick, 2021). Computer-mediated interactions may help to level the playing field between autistic and non-autistic individuals by reducing social/time pressure and the need to interpret non-verbal cues such as facial expressions. Given autistic individuals' preference for computer-mediated interactions and the increasing prevalence of online communication, it is timely to understand how autistic and non-autistic individuals create and negotiate meaning across various online communication channels.

Summing up, this study aims to answer three key research questions:

RQ1. Communication efficiency: During a referential communication task, do dyad participants succeed at communicating efficiently (manifested as a decrease in duration and words produced across rounds)?

RQ2. Impact of neurotype (mis)match: How does neurotype (mis)match impact communication efficiency when dyad members are unaware of their partner's neurotype?

RQ3. Impact of communication mode: Do we also find an effect of neurotype (mis)match on communication efficiency when dyad members communicate in writing?

To address these questions, we conducted an online referential communication task (Director Task) assessing how neurotype matching (same- vs mixed-neurotype) influences communication efficiency (measured as task duration and verbosity) across oral and written communication modes. Importantly, participants were unaware of their partner's diagnosis, allowing us to observe natural communication patterns. In line with previous research, we formulated the following hypotheses:

H1. We expect duration and word count to decrease across rounds for all dyad types, indicating improved communication efficiency over time.

H2. We hypothesized that Directors in mixed-neurotype dyads would be less efficient in achieving mutual understanding during the referential communication task than same-neurotype dyads, taking longer to complete the task and using more words compared to same-neurotype dyads (both autistic and non-autistic dyads). We did not have strong predictions regarding potential differences in these measures of communication efficiency between autistic/autistic and non-autistic/non-autistic interactions. On the one hand, previous research has suggested that autistic/autistic interactions may rely less on non-autistic social conventions to achieve shared meaning (e.g. Heasman & Gillespie, 2019). Therefore, we could expect verbal behaviors to be different between autistic and non-autistic interactions. On the other hand, Crompton, Ropar, et al. (2020) did not find any difference in information transfer between autistic and non-autistic pairs, suggesting possible parity in communication efficiency between autistic and non-autistic interactions. Given these findings, we remained open to either outcome in our study.

H3. By analyzing communication efficiency in two distinct conditions (oral and written communication), we can examine the effect of neurotype (mis)match in different communication modes. In face-to-face mixed-neurotype interactions, autistic individuals face a "double-whammy": processing a different communication style and dealing with the time and social pressure of face-to-face interactions. If written communication alleviates these difficulties, we might expect the impact of neurotype mismatch to disappear when participants interact in writing to complete the referential communication task. Conversely, if there is an effect of neurotype *mismatch in both communication modes, it would suggest that there is an inherent difference in the way autistic individuals communicate that affects both speech content and style.*

By not disclosing partners' diagnoses, we can also test the prediction that the distinct verbal behaviors in mixed-neurotype interactions, as opposed to same-neurotype ones, are primarily influenced by fundamental differences in the communication styles of autistic and non-autistic individuals, and not just by the influence of interacting with a different neurotype.

Finally, the referential communication task led to conversations that revolved either around image description or small talk. This design allowed us to conduct exploratory analyses on how these two topics of discussion influenced the verbosity of the Director. This aspect of our study was exploratory in nature, and we did not have any specific a priori predictions regarding potential differences in verbal behavior between image description and small talk.

Materials and methods

This study was approved by the Ethics Committee Erasme Hospital (A2021/056) and written informed consent was obtained from each of the study's participants. There was no active community involvement in this study.

Participants

Autistic participants were recruited from our database, through the Autism Reference Center at the Hôpital Universitaire des Enfants Reine Fabiola, our partner institutions and associations, via advertisement on our website and Facebook group and/or by word of mouth. Non-autistic participants were also recruited from our database as well as via advertisement on our website and Facebook group and/or by word of mouth. Table 1 shows an overview of participants' characteristics.

Inclusion criteria for all participants were: (1) to be 18 years or older and (2) French-speaking. Autistic participants needed to have a clinical diagnosis of autism. On average, autistic participants were diagnosed in early adulthood (M = 31.88, SD = 12.89). Non-autistic participants should not have a current history of psychiatric or neurological issues.

Within dyads, participants were strictly matched on sex and as closely as possible on age. While we achieved to match on age within dyads, there was a significant difference in age across dyads, with participants in non-autistic dyads being significantly younger than participants in autistic and mixed dyads ($t = -6.48$, $p < .0001$; $t = -4.34$, $p < .0001$). There was no significant age difference between participants in autistic and mixed dyads ($t = 1.99$, $p = 0.12$; see Table 1).

To describe the demographic profile and socio-cognitive traits of the participants, they completed several questionnaires. These included a French translation of the revised Family Affluence Scale (Hartley et al., 2016; Torsheim et al., 2016), as well as the French versions of the Autism Quotient (AQ, Baron-Cohen et al., 2001) and the Systemizing Quotient (SQ, Wheelwright et al., 2006). These questionnaires were administered remotely via the Limesurvey platform (*LimeSurvey—Free Online Survey Tool*, n.d.), which unfortunately resulted in some missing data due to participants not completing the questionnaires. Specifically, there was missing data from five autistic and five non-autistic participants for the AQ, and from nine autistic and seven non-autistic participants for the SQ. At the moment of testing, 71,6% of the participants lived in Belgium ($N = 96$), 25,3% lived in France ($N = 34$) and 0.7% lived in Israel ($N = 1$).

A t-test revealed that there were no significant differences in the FAS-III scores of autistic and non-autistic participants ($t = -1.37$, $p = 0.17$). Regarding AQ and SQ scores, a t-test revealed a significant difference between

Table 1. Descriptive statistics for autistic, non-autistic, and mixed-neurotype dyads.

	Autistic dyads	Non-autistic dyads	Mixed dyads	
	$N_{participant =}$ 46	$N_{participant =}$ 46	$N_{participant}$ = 42	
			Autistic	Non-autistic
Sex	*F* = 32; M = 14	*F* = 38; M = 8	*F* = 13; M = 8	*F* = 13; M = 8
Age	37.24 (11.86)	23.76 (8.47)	33.71 (8.93)	32.29 (9.64)
Range	18-63	18-54	19-60	19-60
AQ	37.49 (6.63)	17.91 (7.54)	36.63 (5.44)	15.19 (6.28)
SQ	64.12 (11.52)	54.93 (12.89)	62.00 (10.45)	54.18 (17.06)
FAS	10.45 (2.66)	10.42 (2.41)	9.26 (2.70)	11.41 (2.03)
FSIQ	124.29 (12.82)	106.65 (13.03)	121.55 (9.45)	109.89 (14.09)
VCI	126.82 (13.43)	106.33 (14.83)	122.91 (17.29)	111.44 (15.07)
PRI	117.38 14.88	103.12 (11.12)	113.45 (14.26)	103.00 (13.83)
WMI	113.84 (14.13)	105.37 (13.54)	106.70 (10.59)	108.56 (15.32)
PSI	111.55 (15.54)	106.65 (15.25)	109.27 (18.70)	107.94 (14.27)

autistic and non-autistic participants ($t = 16.41$, $p < .0001$ and $t = 3.77$, $p < .001$, respectively). As can be seen from Table 1, autistic participants had significantly higher AQ and SQ scores than non-autistic participants, supporting the assumption that at the group level, autistic, and non-autistic individuals have distinct socio-cognitive profiles.

Where possible, we also collected IQ scores from the French version of the Wechsler Adult Intelligence Scale-fourth edition (WAIS-IV; Wechsler, 2008). To maximize our chances of recruiting the number of participants estimated by our power analyses ($N = 132$, see Supplementary Material), we recruited French-speaking participants from all over Belgium and France. This meant that for some participants who lived close to Brussels, we were able to meet them in person to administer the WAIS-IV, but for others who lived further away, we were unable to meet them in person. For those we did not see in person, we asked them if they would be willing to share their neuropsychological assessment with us including their WAIS-IV scores if they had them available. As a result, we obtained Full-scale IQ (FSIQ) scores from 46 autistic and 61 non-autistic participants, Verbal Comprehension Index (VCI) and Perceptual Reasoning Index (PRI) scores from 45 autistic and 61 non-autistic participants each and Working Memory Index (WMI) and Processing Speed Index (PSI) scores from 42 autistic and 61 non-autistic participants each.

As can be seen from Table 2, all three dyad types differed in FSIQ and VCI scores. For PRI scores, autistic dyads differed significantly from non-autistic and mixed-neurotype dyads but there was no difference between the PRI scores of mixed-neurotype dyads and non-autistic dyads. For WMI scores, only autistic and non-autistic dyads differed significantly from each other. Finally, there were no significant differences in the PSI scores of the three dyad types.

Materials

The stimuli in this task are 40 unlexicalized, abstract images (see Images I and 2). The set of stimuli is based on the materials used by Yoon and Brown-Schmidt (2018). A subset of the images was previously used in several other studies (Arnold et al., 2007; Brown-Schmidt, 2009). A different set of 10 abstract images was used with each role change.

Table 2. Post hoc comparisons of the IQ scores (WAIS-IV) for autistic, non-autistic, and mixed-neurotype dyads.

	Autistic dyads—mixed dyads		Autistic dyads—non-autistic dyads		Mixed dyads—non-autistic dyads	
	t	*p*	*t*	*p*	*t*	*p*
FSIQ	3.03	<.01	5.90	<.0001	2.43	.04
VCI	2.92	.01	5.99	<.0001	2.64	.03
PRI	3.07	<.01	4.64	<.0001	1.19	0.46
WMI	1.67	0.22	2.64	.03	0.76	.73
PSI	0.78	.72	1.34	.38	0.48	.88

Image 2. Screenshot of the screen display of the Director.

Procedure

We conducted a standard referential communication task, the Director Task (DT), in which two participants collaborated to reorder a set of unlexicalized abstract images. The DT was conducted entirely online via a computer interface, where dyad members logged on to a server hosting the DT (https://www.refcommacte.com). Participants with an even-number identifier (102) received the role of Director, and participants with an uneven-number identifier (ex. 103) received the role of the Matcher. Depending on the type of communication mode, participants were either prompted to activate the microphone of their computer (oral communication) or informed that they would communicate via a live chat (written communication). Participants had to click on “Ready” to proceed to the first block of the experiment.

The Director’s screen displays a set of 10 abstract images, organized in a specific order. The Matcher’s screen displays the same set of images at the top (in a different, random order). Image 2 shows an illustration of the screen display of the Director. The Director instructs the Matcher to rearrange the images in the same order as displayed on their screen. The Director typically drives the conversation, but both the Matcher and the Director can freely discuss the images. The Director and Matcher play five rounds with the same set of abstract images but in a different order per round. Then, the roles of the Director and Matcher are reversed, so that the Matcher becomes the Director, and vice versa. The aim of the task remains the same but is performed with a new set of abstract images.

Dyad members executed this task using two communication modes: spoken and written. For both communication mode, the task goal and procedure were the same (as described above). The only difference was the channel through which the interaction takes place; namely, oral communication (via a microphone, no video) or written communication (via a live chat). Communication mode was counterbalanced across dyads: 33 dyads began the task orally and 34 dyads began the task in writing.

To summarize, the DT was organized into four blocks: two blocks of oral communication and two blocks of written communication. Each block consisted of five rounds. In each block, participants played with the same set of 10 stimuli, albeit the order of the stimuli changed every round. After five rounds, the roles switched: the Matcher becomes the Director and the (old) Director becomes the Matcher. Each dyad member played 20 rounds in total, 10 as a Director (five in each communication mode) and 10 as a Matcher (five in each communication mode). All dyads performed this task successfully achieving an average accuracy rate of 99% (see Table 3 below).

After completing the DT, participants took part in a get-to-know task and filled in a rating questionnaire. Get-to-know and rating results will be presented in a separate paper. After completing the DT, participants filled in the demographic, AQ, and SQ questionnaires.

Transcription and coding

All audio recordings were first automatically transcribed using Whisper OpenAI (Radford et al., n.d.). Transcriptions were then manually checked by PG and SJ and modified if needed to render an accurate orthographic transcription of the audio (see Supplementary Material for orthographic transcription guidelines). Orthographic transcriptions were subsequently transferred into an Excel sheet for coding. Chat transcripts were transferred from a text file into an Excel sheet for coding. As we were interested in the Director’s verbal behavior and how they described the images, the productions of the Matchers were not analyzed.

The first author of the manuscript (not blind to the diagnosis of participants) coded the words used by the Director into “image description” or “small talk.” This coding was done on the word level. The category “image description” included all words used in the initial description (before any comments of the Matcher) as well as words used for clarification of the image description. The category “small talk” included all words that were not used for image description such as participants introducing themselves, greeting each other, and task-related comments (e.g. telling the participant that they are reading the instructions or that they find the task fun/boring) and supportive comments (e.g. congratulating the other participant on their description).

Results

Analysis plan

All analyses were conducted in *R* (R Core Team, 2021). The two outcome measures were: task duration, as the time (in seconds) taken to complete the task, and verbosity, the total number of words produced by the Director. We used the function glmmTMB from the package “glmmTMB” (Brooks et al., 2017) to fit Generalized Linear

Table 3. Average accurate rate (in percentage, standard deviation in brackets) across dyad type.

	Autistic dyads	Non-autistic dyads	Mixed-neurotype dyads
Accuracy rate	99.40 (3.43)	98.90 (6.19)	98.98 (5.41)

Mixed Models (GLMMs). The function glmmTMB can handle various types of response variables including count data (verbosity) and continuous (duration). To examine whether dyads succeeded in communicating effectively during the referential communication task (i.e. decrease in time and verbosity across turns), we included the variable round order (1-5) in our four models.

In modeling the Director's verbosity, the dependent variable is the aggregated number of words produced by the Director. We first assessed if there was overdispersion using the dispersiontest function from the "AER" package (Kleiber & Zeileis, 2008). Given significant overdispersion in our data ($z = 10.45$, $p < .001$) relative to what would be expected under a Poisson distribution, we modeled our data using a Negative Binomial distribution. To examine neurotype matching on verbosity, the Director's and Matcher's diagnoses were added as predictor variables in our models for verbosity, as well as their interaction. This allows us to examine both whether the Director's own diagnosis and one of their partner's diagnoses influence verbosity (Ledermann & Kenny, 2017). Furthermore, to account for our data's nested nature, we included the dyad ID as a random intercept. Finally, discussion topic was added as a fixed effect to distinguish between the number of words used to describe the images and those for "small talk."

In modeling task duration, the dependent variable was round duration. Round duration was positively skewed, and we modeled our data using a Gamma distribution which is most suitable when dealing with positively skewed, continuous data such as time. We also included the fixed effect of dyad type. Round durations were automatically calculated via an algorithm of the referential communication task, accounting for the entire dyad as a unit. This means that while we have a time estimate for the dyad's overall performance, we could not distinguish the individual contributions of the Director and Matcher to the overall measure of round duration. Therefore, unlike our approach with the verbosity models, where we could assess the impact of each partner's diagnosis, the task duration models do not allow for an analysis of the separate influence of each partner's diagnosis.

Finally, in each of the four models, we incorporated two additional control variables: communication mode order and director order. Since one communication mode came before/after the other, and one participant was the director first, we controlled for these factors by treating the order of communication and the order of the director as fixed effects in all four models. By controlling for these variables, we ensured that differences in word count and round duration could be attributed to dyad types and/or the interaction of the Director's and Matcher's diagnoses (and not due to aspects of our experimental design). All significant effects reported in this article remained so after controlling for these variables.

To evaluate the impact of our variable on verbosity and task duration, we employed the "drop1" function from the base package "stats" (R Core Team, 2021). This function operates by systematically removing one predictor at a time from the model, allowing one to assess the change in model fit with each removal. This stepwise process helped us determine if any predictors in the model were not contributing significantly to the model's explanatory power. Post hoc analyses (corrected for multiple comparisons using the Tukey method) were conducted using the emmeans function from the "emmeans" package (Lenth, 2024).

Task duration

Oral communication. Round duration was significantly influenced by the fixed effects of round order (1–5; $\chi^2(4) = 978.61$, $p < .0001$), dyad type (non-autistic vs autistic vs mixed; $\chi^2(2) = 7.69$, $p = .02$) and communication mode order (oral first vs written first; $\chi^2(1) = 17.36$, $p < .0001$). The fixed effect of director order was not significant ($\chi^2(1) = 0.24$, $p = .62$).

Post hoc analyses on round order (summarized in Table 4) show that duration decreased for every round except the last two rounds (rounds four and five). Table 5 shows the mean duration of each round.

Post hoc analyses on dyad type reveal that non-autistic dyads were overall faster than autistic ($z = -2.41$, $p = .04$) and mixed dyads ($z = -2.45$, $p = .04$). There were no differences in overall round duration between autistic and mixed dyads ($z = -0.10$, $p = 1.0$).

For our control variable, the round duration was longer when the oral communication mode was first than when it was second ($z = 4.17$, $p < .0001$).

Table 4. Summary of post hoc comparisons for round duration in the oral and written communication.

Comparison	z-ratio	
	Oral	*Written*
Round 1—Round 2	26.26***	17.70***
Round 1—Round 3	33.07***	23.75***
Round 1—Round 4	35.84***	26.60***
Round 1—Round 5	36.75***	27.22***
Round 2—Round 3	6.81***	6.03***
Round 2—Round 4	9.59***	8.90***
Round 2—Round 5	10.50***	9.48***
Round 3—Round 4	2.78*	2.86*
Round 3—Round 5	3.69*	3.45*
Round 4—Round 5	0.92	0.58

Signif. codes: .0001 "***" .001 "**" .01 "*" 0.05 "."

Table 5. Mean round duration in seconds (standard deviation in brackets) for each round (1–5) across modalities and dyad types.

	Oral communication			Written communication		
	Autistic	*Non-autistic*	*Mixed*	*Autistic*	*Non-autistic*	*Mixed*
1	167.98 (66.87)	139.90 (54.32)	170.82 (58.20)	470.20 (234.41)	361.16 (213.39)	477.62 (341.36)
2	58.50 (21.53)	57.10 (20.45)	60.12 (25.57)	150.02 (88.85)	137.86 (96.95)	181.45 (136.76)
3	46.34 (14.06)	42.90 (13.71)	45.85 (11.51)	114.46 (78.72)	92.20 (56.64)	118.71 (79.37)
4	40.93 (13.13)	39.83 (11.30)	40.50 (9.47)	91.17 (43.56)	86.35 (69.47)	93.90 (63.58)
5	38.84 (11.03)	38.43 (11.61)	39.83 (9.00)	86.89 41.87	81.66 (61.50)	90.26 (65.92)

Written communication. Round duration was significantly influenced by the fixed effects of round order ($\chi^2(4)=725.62$, $p<.0001$), dyad type ($\chi^2(2)=22.74$, $p<.0001$), communication mode order ($\chi^2(1)=78.64$, $p<.0001$) and director order ($\chi^2(1)=32.95$, $p<.0001$).

Post hoc analyses of round order (summarized in Table 4) suggest that duration decreased for every round except the last two rounds (rounds four and five). Table 5 shows the mean duration of each round.

Post hoc analyses on dyad type suggest that non-autistic dyads were overall faster than autistic ($z=-3.44$, $p<.01$) and mixed dyads ($z=-4.62$, $p<.0001$). There were no differences in overall round duration between autistic and mixed dyads ($z=-1.24$, $p=.43$).

For our control variables, round duration was longer when written communication was first then when it was second ($z=9.16$, $p<.0001$). Likewise, round duration was overall longer for the first directors than the second directors ($z=5.81$, $p<.0001$).

Verbosity (number of words) of the Director

Oral communication. Director verbosity was significantly influenced by the fixed effects of round order ($\chi^2(4)=4379.7$, $p<.0001$) and director order ($\chi^2(1)=100.2$, $p<.0001$); there was also a triple interaction between director diagnosis, matcher diagnosis and topic of discussion ($\chi^2(1)=20.7$, $p<.0001$). The effect of modality order was not significant ($\chi^2(1)=2.9$, $p=.09$).

Post hoc analyses on round order (summarized in Table 6) show that verbosity decreased across each round. Following up on the triple interaction, post hoc analyses (summarized in Table 7 and visualized in Figure 1) show that there was no difference in verbosity regarding image description between same-neurotype dyads. Within mixed dyads, however, autistic directors used more words to describe images than non-autistic directors.

A similar pattern emerges for verbosity in "small talk." There were no significant differences between same-neurotype dyads. Within mixed dyads, autistic directors were more verbose than non-autistic directors. Furthermore, autistic directors from mixed dyads were more verbose than autistic directors from autistic dyads and non-autistic directors from non-autistic dyads. Non-autistic directors from mixed dyads were not more verbose than non-autistic directors from non-autistic dyads and autistic directors from autistic dyads. Table 8 shows a summary of mean words per neurotype matching.

Finally, regarding our control variable, there was also a significant effect of director order: "first" directors produced more words overall than second directors ($z=10.00$, $p=<.0001$).

Table 6. Post hoc comparisons of verbosity per round across oral and written modalities.

Comparison	z-ratio	
	Oral	*Written*
Round 1—Round 2	40.24***	38.18***
Round 1—Round 3	53.26***	48.12***
Round 1—Round 4	58.24***	51.51***
Round 1—Round 5	60.91***	53.68***
Round 2—Round 3	14.21***	10.91***
Round 2—Round 4	19.85***	14.92***
Round 2—Round 5	22.64***	17.81***
Round 3—Round 4	5.74***	4.08***
Round 3—Round 5	8.52***	6.71***
Round 4—Round 5	2.77*	2.63

Signif. codes: .0001 "***" .001 "**" .01 "*" 0.05 "."

Written communication. Verbosity was significantly influenced by the fixed effects of round order ($\chi^2(4)=3756.6$, $p<.0001$), director order ($\chi^2(1)=270.4$, $p<.0001$) and communication mode order ($\chi^2(1)=14.9$, $p<.0001$) as well as the triple interaction between directors' diagnosis, matcher's diagnosis and topic of discussion ($\chi^2(1)=35.7$, $p<.0001$).

Post hoc analyses of round order (summarized in Table 6) show that verbosity decreased across each round, except the last two rounds (rounds four and five). Following up on the triple interaction, post hoc analyses (summarized in Table 9 and visualized in Figure 2) reveal that, within mixed dyads, autistic directors were more verbose in describing images than non-autistic directors; there were no differences between directors of same-neurotype dyads.

Table 7. Post hoc analyses of total number of words produced in oral communication.

Image			Small talk		
	z	p		z	p
Au[a]-same—NonAu[b]-same	-0.33	1.00	Au-same—NonAu-same	0.85	0.99
Au-same—NonAu-mixed	0.46	1.00	Au-same—NonAu-mixed	−0.60	1.0
Au-same—Au-mixed	-0.84	1.00	Au-same—Au-mixed	−4.07	.001
NonAu-same—NonAu-mixed	0.78	1.00	NonAu-same—NonAu-mixed	1.32	0.89
NonAu-same—Au-mixed	-0.53	1.00	NonAu-same—Au-mixed	−4.76	.0001
NonAu-mixed—Au-mixed	-3.50	0.01	NonAu-mixed—Au-mixed	−3.71	.005

[a]Autistic.
[b]Non-autistic.

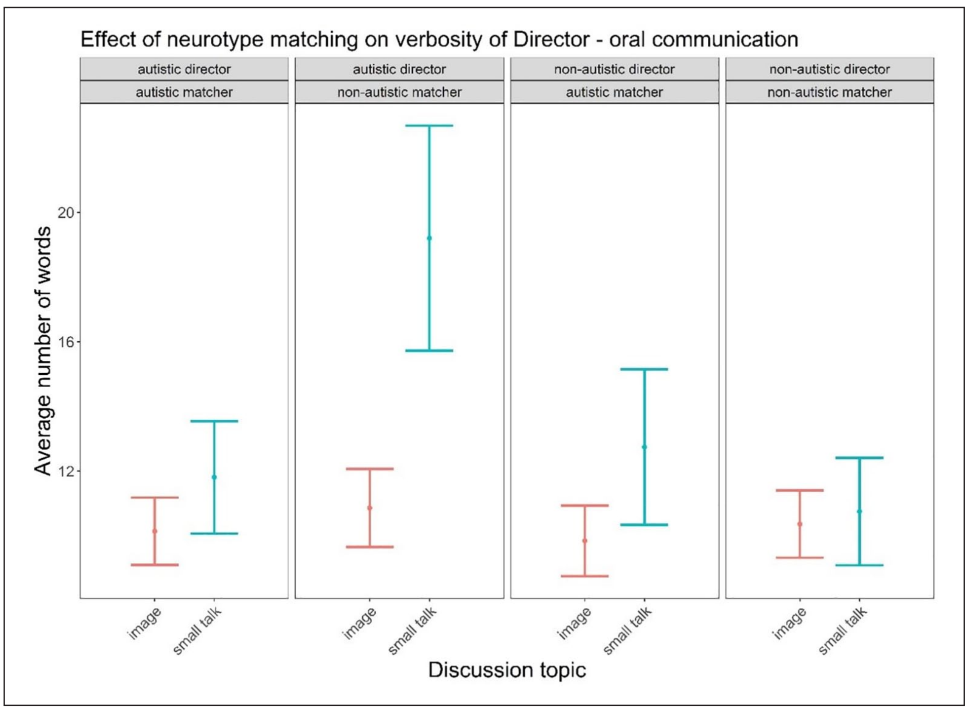

Figure 1. Fitted 95% CIs of the triple interaction between director diagnosis, matcher diagnosis, and discussion topic during oral communication.

Table 8. Mean words for image description and small talk per partner diagnosis and communication mode.

		Oral communication				Written communication			
		Image		Small talk		Image		Small talk	
		Matcher							
		Au	NonAu	Au	NonAu	Au	NonAu	Au	NonAu
Director	Autistic (Au)	12.29 (13.75)	13.07 (14.59)	17.67 (26.40)	27.79 (39.67)	5.67 (6.11)	6.21 (7.83)	7.77 (7.88)	15.00 (25.78)
	Non-Autistic (NonAu)	11.53 (11.75)	12.15 (11.95)	16.88 (25.91)	17.85 (33.27)	5.25 (5.56)	5.33 (5.01)	10.07 (11.39)	8.35 (11.16)

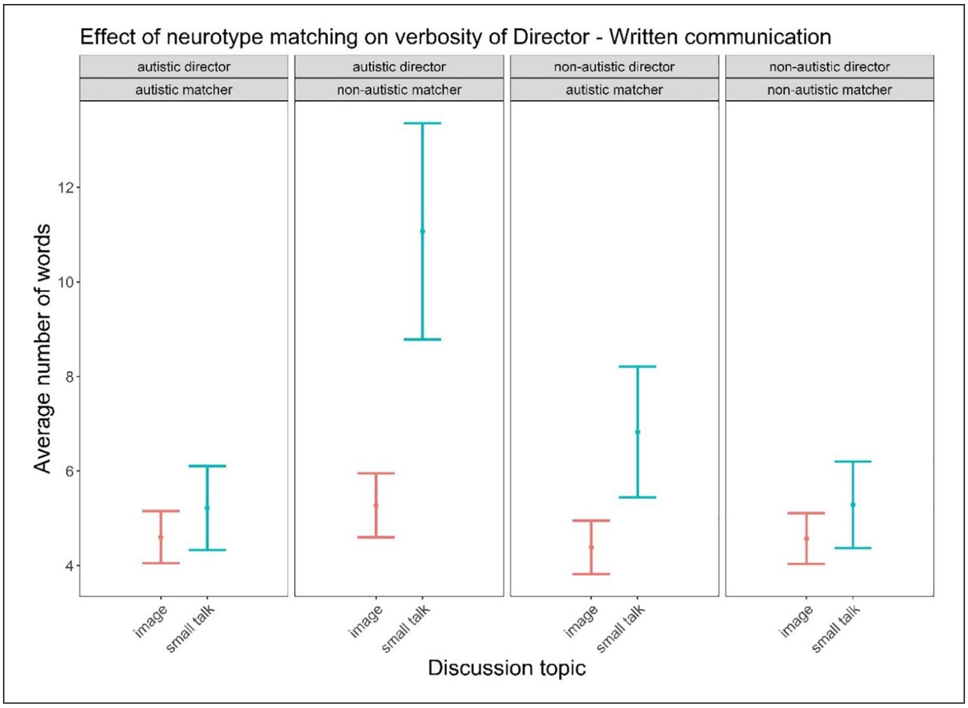

Figure 2. Fitted 95% CIs of the triple interaction between director diagnosis, matcher diagnosis and discussion topic during written communication.

Table 9. Post hoc analyses of total number of words produced in written communication.

Image			Small talk		
	z	*p*		*z*	*p*
Au-same—NonAu-same	0.07	1.00	Au-same—NonAu-same	−0.10	1.00
Au-same—NonAu-mixed	0.54	1.00	Au-same—NonAu-mixed	−2.00	0.49
Au-same—Au-mixed	−1.52	0.79	Au-same—Au-mixed	−5.51	<.0001
NonAu-same—NonAu-mixed	0.47	1.00	NonAu-same—NonAu-mixed	−1.88	0.56
NonAu-same—Au-mixed	−1.61	0.74	NonAu-same—Au-mixed	−5.37	<.0001
NonAu-mixed—Au-mixed	−6.65	<.0001	NonAu-mixed—Au-mixed	−4.13	<.001

For small talk, again, there were no significant differences between directors in the same-neurotype dyads. Within mixed dyads, autistic directors were more verbose than non-autistic directors. Furthermore, autistic directors from mixed dyads were more verbose than autistic directors from autistic dyads and non-autistic directors from non-autistic dyads. Non-autistic directors from mixed dyads were not more verbose than non-autistic directors from non-autistic dyads and autistic directors from autistic dyads. Table 8 shows a summary of mean words per neurotype matching.

Finally, regarding our control variables, there were significant effects of communication mode and director order. Overall, Directors were more verbose when the written communication mode came first than second ($z = 4.09$, $p < .0001$). Likewise, "first" directors were more verbose than "second" directors ($z = 16.57$, $p = < .0001$).

Discussion

This study investigated communication efficiency (measured in terms of task duration and verbosity) in an online referential communication task across autistic, non-autistic, and mixed-neurotype dyads, broadening our understanding of cross-neurotype interactions in face-to-face settings to include both oral and written computer-mediated interactions. Our results suggest that neurotype mismatch (i.e. being in a mixed-neurotype dyad) influenced the verbosity of autistic Directors but not those of non-autistic Directors. However, neurotype mismatch did not impact task duration, as both autistic/autistic dyads and mixed-neurotype dyads were slower to complete the task than non-autistic/non-autistic dyads. We will discuss this pattern of results in relation to our research questions and initial hypotheses below. Given the similarity of results across communication modes, we will first approach the discussion of task duration and verbosity in a general manner for clarity, before presenting the wider implications that these results may have.

Regarding our first research question, our results support our hypothesis: All dyad types demonstrated improved communication efficiency throughout the task, as evidenced by decreases in both task duration and word count across successive rounds. Regarding our second research question, our results partially confirm our predictions. For task duration, contrary to our initial hypothesis, mixed-neurotype dyads did not take more time to complete the Director Task than same-neurotype dyads (both autistic and non-autistic dyads). Our findings reveal that non-autistic dyads were most efficient at executing the Director Task, being overall faster than autistic and mixed-neurotype dyads. This indicates that dyads with at least one autistic participant performed the Director Task more slowly overall than dyads with no autistic participants. These observations align with the studies of Georgescu et al. (2020) and Wadge et al. (2019), which reported that pairing of autistic individuals did not enhance the coordination/alignment of their non-verbal behaviors compared to when they were paired with non-autistic individuals. Taken together, these results suggest that when we look at non-verbal aspects of interactions, there is no evidence for better outcomes in same-neurotype dyads compared to mixed-neurotype dyads. These findings also raise a methodological consideration: evaluating dyads as single units (and as a single factor in statistical models) without analyzing the influence of each partner separately (and their interaction in statistical models) could mask distinct impacts of neurotype mismatch for autistic and non-autistic individuals.

Regarding Director's verbosity, our study confirms and nuances our initial hypothesis that mixed-neurotype dyads would produce more words than same-neurotype dyads. A key finding of our study is that neurotype mismatch (i.e. being in a mixed-neurotype dyad) influenced the verbosity of autistic and non-autistic Directors differently. Within mixed-neurotype dyads, autistic Directors produced more words than non-autistic Directors, and this effect was strongest for small talk. Crucially, we did not see this pattern for non-autistic Directors (in mixed-neurotype dyads) who were not more verbose than autistic and non-autistic Directors from same-neurotype dyads. In other words, being paired with a partner of a different neurotype increased verbosity only for autistic individuals.

The means in Tables 8 and 9 suggest that the increase in verbosity was equivalent to 1 to 2 words for image descriptions and 5 to 11 words for small talk. While these differences might seem minor in real-life contexts, previous research has suggested that subtle differences in the discourse style of autistic individuals can nevertheless have an impact on how they are perceived (e.g. Canfield et al., 2016; Geelhand et al., 2021; Stagg et al., 2023). Therefore, we believe that the observed differences in verbosity are likely to contribute to the perception of a different communication style and subsequent difficulties in mixed-neurotype interactions. Although we could not analyze the causes of this increase in verbosity within the context of this study, we can offer a few possible explanations. For image descriptions, this increase in verbosity might stem from non-autistic Matchers struggling to understand the explanations provided by autistic Directors, prompting the former to ask more questions and the latter to offer more explanations. For small talk, however, increased verbosity could rather reflect more communicative efforts on the part of autistic Directors to manage the interaction. Although speculative, this explanation aligns well with the assumption that autistic individuals, out of necessity, have developed a deeper understanding of non-autistic people's communication preferences, more so than non-autistic individuals have of autistic people (Cummins et al., 2020; Milton, 2012). To test these hypotheses and identify the exact reasons behind the increased verbosity of autistic individuals in mixed-neurotype dyads, a more detailed linguistic analysis of both the Director's and the Matcher's speech is needed.

Regarding our predictions for same-neurotype dyads, we found no significant differences between autistic and non-autistic dyads both for image description and small talk. Extending the findings of Crompton, Ropar, et al. (2020), our study shows that pairs of autistic participants are as adept as pairs of non-autistic participants at information exchange in the context of a collaborative task. More specifically, the lack of difference in verbosity for both image description and small talk suggests that autistic and non-autistic dyads demonstrated equal efficiency in communicating to achieve the task's objectives and in managing the flow of their interactions. These observations provide additional support to the view that communication challenges in autism cannot be solely attributed to autistic individuals (Milton, 2012).

Relating these results to those of task duration, our study suggests there is no clear relationship between temporal and verbal efficiency in autistic dyads. One hypothesis is that the interactions of autistic people included more silent pauses and/or longer silent pauses than the interactions of non-autistic adults. Although this hypothesis needs to be verified with detailed discourse analysis, it is plausible considering previous findings suggesting that autistic/autistic interactions include more long silent pauses (Wehrle, Vogeley, et al., 2023) and longer silent gaps in the earliest stage of dialogue than non-autistic/non-autistic interactions (Wehrle, Cangemi, et al., 2023).

Finally, regarding our third research question, the aforementioned pattern of results was consistent regardless of whether participants communicated orally or in writing (even after controlling for order of communication mode).

Regarding our initial expectations about communication mode, these findings support the assumption that the communication styles of autistic and non-autistic adults differ inherently, and these differences persist even without nonverbal cues such as prosody or facial expressions. In addition, our results suggest that neurotype mismatch persists even in communicative settings with reduced time and social pressure.

Limitations

Our study has several limitations that offer directions for future research. First, our sample consisted of cognitively able adults with a majority of female participants, limiting the representativeness and generalizability of our findings. However, the similar female ratio across our three dyad groups ensured comparability among them; a disparity in female ratios would have posed a greater issue. Future research should replicate our study with a more diverse sample to better understand interactions across neurotype.

In addition, non-autistic dyads were significantly younger than autistic and mixed-neurotype dyads. We recommend that future studies aim for more carefully age-matched dyad types. Despite this, we believe the age difference had little impact on our results for several reasons. First, there were no differences between same-neurotype dyads: both younger non-autistic dyads and older autistic dyads behaved similarly across both communication modes. Furthermore, the age ranges of the three dyad types (autistic: 18–63; non-autistic: 18–60; and mixed: 19–60) are similar, suggesting overlap. Likewise, although autistic dyads had a higher VCI than non-autistic dyads, they did not differ in a number of words they produced to describe the images or for small talk. Thus, it does not appear that higher VCI led to more elaborate descriptions. Taken together, it is unlikely that age and VCI acted as a confounding factor in dyad comparisons.

Finally, the conversations in this study were task-oriented, where mutual understanding is crucial to successfully execute the task. Communication strategies can be influenced by the type of conversation (e.g. task-oriented vs affiliative; Dideriksen et al., 2023). Therefore, future studies should examine and compare outcomes across different contexts to provide a more nuanced understanding of interaction dynamics across neurotypes.

Conclusion

Notwithstanding these limitations, our results enable us to draw four important conclusions. First, same-neurotype interactions are successful across a wide range of communication settings, including both face-to-face interactions and computer-mediated interactions. Second, our consistent results across communication modes also suggest that even in situations where social pressure and a need to interpret facial expressions are diminished, neurotype mismatch impacts the verbal behavior of autistic individuals. Third, if we link this conclusion to the fact that the participants were unaware of their partner's diagnosis, the results of our study suggest that the communication style of autistic and non-autistic adults are inherently different, as it transpires even without diagnostic disclosure and the presence of non-verbal cues such as prosody or facial expressions. Finally, our results on verbosity highlight the usefulness of looking at the influence of interaction partners separately in mixed-neurotype dyads, as neurotype mismatch did not impact autistic and non-autistic individuals similarly.

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Author contributions

P.G. secured funding, designed the study, recruited participants, processed and analyzed the data and drafted the manuscript. F.P. recruited participants and gave feedback on the drafts of this manuscript. S.J. helped process the data and gave feedback on the drafts of this manuscript. M.K. secured funding, helped with the design of the study and gave feedback on the drafts of this manuscript.

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Supplemental material

Supplemental material for this article is available online.

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