Non-Autistic People Accurately Recognize Autistic People's Emotional Expressions: Implications for Internal Representations

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Dedicated to Rauno A. Lampi, Ph.D.

The Original Dr. Lampi

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Abstract

Feeling heard and understood by others is an important and meaningful part of social interaction. But many autistic people are misunderstood by non-autistic interlocutors, to the detriment of the quality of that social interaction as well as the autistic person's overall well-being. One way that autistic people are misunderstood is in how their emotions are interpreted by other people, an experience autistic people have described as distressing. In this dissertation, I investigate one possible explanation for why these misunderstandings occur—namely, differences in internal representations of emotional facial expressions between autistic and non-autistic people. In five studies ($N = 1{,}188$), I found that non-autistic participants recognized the posed emotional expressions of autistic people *better* than those of non-autistic people and investigated the factors that contribute to this higher recognition accuracy. These findings are not compatible with the hypothesis that autistic people have different internal representations from non-autistic people, and therefore, this cannot be an explanation for why non-autistic people misunderstand autistic people's emotions in live interactions. I conclude by considering why non-autistic posers were recognized less accurately than autistic posers, and offer alternative explanations for why non-autistic people misunderstand autistic people's emotions.

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Introduction

Autism is a neurodevelopmental condition characterized by differences in social communication and interaction and the presence of repetitive behaviors and/or specialized interests (APA, 2013). Autistic[1] people are typically characterized (by non-autistic researchers) as awkward, distant, and having poor social skills (e.g., Lord & MaGill-Evans, 1995; Weiss & Harris, 2001). For example, in the early documentation of what is now known as autism, Kanner (1943) described how some autistic children have an "inability to relate themselves in the ordinary way to people" (p. 242). Others describe how autistic children have a difficult time understanding the mental or emotional states of non-autistic people (e.g., Baron-Cohen et al., 1985, 1997), leading some researchers to describe autistic people as exhibiting "mindblindness" towards non-autistic people (Senju et al., 2009; see Dinishak & Ahktar, 2013 for a critique of this metaphor).

Because of these noticeable social differences from non-autistic people, cross-neurotype interactions–those between autistic and non-autistic people–are often characterized as awkward, difficult, or unsuccessful (e.g., Travis & Sigman, 1998). Historically, the difficulties that arise in these interactions are assumed to be the fault of the autistic person (e.g., Knott et al., 2006). For example, some researchers have argued that autistic people's unsuccessful social interactions with non-autistic people stem from perspective-taking difficulties (e.g., Baron-Cohen et al., 1985; Peterson et al., 2007; but see Gernsbacher & Yergeau, 2019), or because autistic people lack the motivation to interact with others (e.g., Chevallier et al., 2012; but see Jaswal & Akhtar, 2018).

[1] I use identity-first language because a majority of autistic people prefer it (e.g., Bury et al., 2020; Kenny et al., 2015; Taboas et al., 2022) and because the use of person-first language may accentuate the stigma associated with autism (Gernsbacher, 2017).

More recently, however, some autism scholars have pointed out that interactions are reciprocal: If autistic people contribute to difficulties in cross-neurotype interactions, so too do non-autistic people (Gernsbacher, 2006). According to Milton (2012), this concept–called the "double empathy problem"—highlights the bi-directional nature of this relationship. Indeed, autistic people report that their interactions with non-autistic people can feel awkward or exhausting (e.g., Robison, 2011), often because it seems that the non-autistic member of the interaction is unwilling or unable to understand the autistic person's point of view (e.g., Crompton, Hallett, et al., 2020).

A recent line of empirical work on the double empathy problem has confirmed that non-autistic people do not always have a good understanding of autistic people's minds. For example, non-autistic people have trouble both transmitting information to and receiving information from autistic people (Crompton, Ropar, et al., 2020). Non-autistic people have difficulty taking the perspective of their autistic relatives (Heasman & Gillespie, 2018). And non-autistic people are less accurate at determining what mental state autistic compared to non-autistic people are trying to convey (Edey et al., 2016).

In this dissertation, I investigate one factor that could contribute to non-autistic people's difficulty understanding autistic minds—namely, a difficulty correctly identifying from facial expressions what emotions autistic people are feeling. As will be described below, the two previous studies by other researchers that served as the foundation for this dissertation came to different conclusions: One study found that non-autistic people did not have difficulty recognizing autistic people's emotional expressions (Faso et al., 2015). The other study found that non-autistic people did have difficulty recognizing autistic people's emotional expressions and concluded that the difficulty stemmed from differences in the internal representations for emotional expressions between autistic and non-autistic people (Brewer et al., 2016). These differences in internal representations, if they exist, could lead to misunderstandings in day-to-day interactions.

Background

In this section, I first describe past research suggesting that non-autistic people have difficulty recognizing autistic people's facial expressions, using both experimental and experiential evidence. Then, I review literature suggesting one explanation for why this might occur: cross-neurotype differences in internal representations for emotional expressions.

Non-Autistic People's Difficulty Understanding Autistic People's Emotions

As noted, autistic people have described a feeling of being misunderstood by non-autistic people (e.g., Crompton, Hallett, et al., 2020; Robison, 2011). One factor that may contribute to these feelings involves the difficulty that non-autistic people have in correctly identifying what emotion an autistic person is experiencing. For example, one autistic respondent in a study by Robledo et al. (2012) reported, "One of the biggest problems [interacting with others] was that I tried to express how I felt and people just didn't understand" (p. 7). Another autistic person explained that they feel misunderstood because non-autistic people expect them to express emotion differently than feels natural to them (@Autisong, 2021). This person went on to explain that the non-autistic people they interact with sometimes expect them to display their emotions more intensely, other times, they felt that their non-autistic peers expected them to be more muted.

Perhaps most troublingly though, is that these misunderstandings about autistic people's emotions can have very real effects on their health and well-being. For example, one autistic person described their experience in trying to secure mental health services: "I just don't show emotion the way other people do so…no one believed there was anything wrong with me or that I needed help" (Camm-Crosbie et al., 2019, p.1436). Clearly, these interactions—in formal or informal settings—and the misunderstandings that accompany them can have a profound impact on autistic people's lives.

To my knowledge, there is only one study that empirically documents these misunderstandings in a setting close to that experienced in situ. Sheppard et al. (2016) videotaped non-autistic and autistic individuals as they were presented with one of four unexpected events: they were told a joke, given a compliment, told a story, or were made to wait briefly. These clips (without audio) were shown to a sample of non-autistic participants, who had to infer from the non-verbal behavior of the people depicted which of the four events (i.e., joke, compliment, story, or waiting) had just occurred. Non-autistic observers were less accurate at inferring what situation autistic compared to non-autistic targets had just encountered–except when the clip showed the reaction to a joke.

Sheppard et al. (2016) did not ask participants to guess what emotion the targets were experiencing, so this study is not a perfect analog for investigating whether non-autistic people have difficulty with understanding from facial expressions what emotion an autistic person is experiencing. Still, the findings suggest that when asked to use an individual's body language and facial expressions to make an inference about what has recently happened to them, non-autistic people have greater difficulty accurately inferring that information from autistic people than from non-autistic people. Thus, one factor that could contribute to non-autistic people's misunderstanding autistic people's emotions may be a mismatch between what non-autistic people expect an expression to look like given a particular emotion and the expression produced by autistic people who are feeling that emotion.

Internal Representations of Emotion

Expectations play a significant role in the experience and expression of emotion (e.g., Clore & Ortony, 1991; Jack, 2013; Russell, 1991). We hold expectations, here called "internal representations," about all aspects of emotions, ranging from which contexts are frequently associated with which emotions (e.g., Robinson & Clore, 2002; Tamir & Bigman, 2018), the ways our bodies feel when we experience certain emotions (e.g., Niedenthal, 2007a, 2007b), and the way faces tend to look when expressing emotions (Binetti et al., 2022; Jack & Schyns, 2015; Keating et al., 2022). Within each of these aspects, there are several sub-components for which we can hold separate internal representations. For instance, when it comes to our internal representations for emotional expressions, we have expectations for things such as the speed with which faces change from neutral to emotionally expressive (e.g., Sowden et al., 2021) as well as for the final appearance of the facial expression itself (Binetti et al., 2022; Jack & Schyns, 2015). This last component, the static appearance of a person's face when they are expressing a given emotion, is the type of internal representation that I focus on in this dissertation.

Of course, anyone who has witnessed another person expressing emotion in real time knows that emotional expressions do not look identical every time they occur. Our internal representations are not a cast from which our expressions are formed, appearing the same way each time an emotion is felt. There are other aspects in the cognitive appraisal process of emotion that influence how any individual emotional state is experienced (e.g., Barrett, 2017; Ortony et al., 1988). Because each experience of emotion is unique, the way that emotional state is expressed on the face could look different each time. But our internal representations for emotional expressions play a role in how those expressions are formed (e.g., Gola et al., 2017; Jack & Schyns, 2017).

Furthermore, internal representations for emotional expressions also play an important component in interpreting what emotions other people are experiencing on the basis of their facial expressions (e.g., Bird & Viding, 2014; Goldman & Sripada, 2005). In fact, recent work has suggested that individual differences in emotion recognition could stem from differences in people's internal representations (Binetti et al., 2022). In this study, participants manipulated computer-generated facial expressions until they matched their internal representations for the emotional expressions of happiness, sadness, anger, and fear. A subset of participants then completed an emotion recognition paradigm where they viewed images that had been created by other participants. Next, the experimenters compared the images participants saw in the emotion recognition portion of the study to the images those participants had themselves created. They found that the more overlap there was between two participants' computer-generated expressions of an emotion, the more likely those two participants were to recognize each other's computer-generated expression.

Given that internal representations play a role in both the production and interpretation of emotional expressions, differences in internal representations between two people could lead to misunderstandings in interactions. For example, early research on emotions suggested "basic" emotional expressions are universal (i.e., what is recognized as an angry face in one part of the world should be recognized as angry in all other cultures as well; Ekman & Friesen, 1971; Ekman & Friesen, 1986; Matsumoto, 1992), which suggests that individuals from disparate cultures also share the same internal representations of those basic emotional expressions. But more recent work has called into question the existence of universal emotional expressions (e.g., Barrett 2011; Gendron et al., 2018) or internal representations.

For example, in work by Jack and colleagues (Jack, Caldara, et al., 2012; Jack, Garrod, et al., 2012), Western, Caucasian participants and East Asian participants were shown images of faces that were digitally manipulated to isolate different features of facial expressions that are thought to be relevant to a particular emotion. For example, one image might be of an otherwise neutral face where the whites of the eyes—relevant to the expression of surprise—were manipulated, while the rest of the expression remained neutral. In another, only the corners of the mouth might be upturned—a component of happiness. For each of these manipulated images, participants had to decide which of six emotion categories each face best represented. Jack and colleagues found that Western Caucasian and East Asian participants had different expectations for what prototypical examples of the six emotion categories looked like. These different expectations led the authors to conclude that the two groups do not share the same internal representations for all emotions.

Since autistic and non-autistic people are sometimes said to represent distinct cultures (e.g., Botha & Frost, 2020; Leadbitter et al., 2021), they might also have different internal representations for emotional expressions. Because of their different ways of experiencing the world, perhaps autistic and non-autistic people have different expectations for how emotions like happiness, sadness, surprise, anger, disgust, and fear (typically considered to be the six "basic" emotions; Ekman & Friesen, 1976; Ekman & Friesen, 1978) appear on the face. The lack of a common representation of facial emotional expression could contribute to the mismatch between autistic people's actual emotional states and non-autistic people's inferences about those emotions.

Some research suggests autistic and non-autistic people may share internal representations for some components of the expression of emotion. For example, one recent study tested whether autistic and non-autistic people have similar representations for the *speed* with which emotional expressions unfold across the face (Keating et al., 2022). In this study, non-autistic adults made angry, sad, and happy expressions which were converted to point-light displays. Autistic and non-autistic participants viewed these displays as the faces morphed from a neutral expression to the end expression. By using a slider, participants manipulated the speed with which the faces took on the expression until that speed matched the participant's representation for how quickly that expression forms on the face. Autistic and non-autistic participants did not differ in their estimates of how quickly faces take on expressions for any of the three emotions. This suggests that autistic and non-autistic people do not have different representations for the mechanics of certain expressions. But, as described earlier, the speed with which an expression unfolds is just one component of the internal representation of an emotional expression. My interests are in whether autistic and non-autistic people have different internal representations for the final appearance of the facial expression itself.

Another study focused more directly on autistic and non-autistic people's static emotional expressions, and found evidence that may suggest the two neurotypes do have different internal representations for emotional expressions (Manfredonia et al., 2019). Autistic and non-autistic participants made emotional expressions which were categorized using software designed to detect which facial muscles are activated when forming expressions. The software detected differences between autistic and non-autistic expressions for some muscle groups (e.g., corners of the lips were less activated in autistic compared to non-autistic expressions of happiness). Differences in the activation of muscle groups relevant to the expression of certain emotions could suggest that participants were drawing on different representations for emotional expressions when creating the expressions. However, these expressions were never evaluated by people, which is crucial if one's intent is to study internal representations.

A more effective way to investigate autistic and non-autistic people's internal representations for emotional states is to use emotion recognition tasks. Recall that internal representations for emotional expressions are involved in *both* the production and perception of those expressions. Therefore, one way to investigate whether two groups have similar internal representations is to use images of people's facial expressions and ask observers from one group to label the emotions being expressed. If members of Group A recognize expressions produced by members of Group A and Group B equally well, this suggests that the two groups share internal representations. The representations used by the people to create the expressions align with the representations used by the people interpreting the expressions. If, however, members of Group A recognize expressions produced by Group A better than those produced by Group B, this suggests that the two groups have different representations of emotion. Finally, a third possibility is that members of Group A could recognize expressions produced by members of Group B better than expressions produced by members of Group A. Before conducting Study 1, this possibility seemed unlikely, and I will defer discussion of the implications of this pattern of results until the discussion of Study 3.

Accordingly, there are two ways to investigate whether autistic people have different internal representations for emotional expressions compared to non-autistic people. One is to investigate whether autistic people have difficulty recognizing non-autistic expressions. As will be discussed below, this approach has been used frequently. However, this approach does not provide insight into my primary interest, which is investigating whether differences in internal representations contribute to why non-autistic people sometimes misunderstand the emotions autistic people experience. To investigate this question requires asking whether non-autistic people have difficulty recognizing expressions produced by autistic people—a procedure that, as described below, has been used much less often.

Autistic People's Recognition of Non-Autistic People's Expressions

At a glance, the literature regarding autistic people's recognition of non-autistic people's emotions suggests that there are differences between autistic and non-autistic people's internal representations for emotional expressions. Compared to non-autistic participants, autistic participants have more difficulty correctly identifying the emotion displayed on non-autistic actors' faces (for recent meta-analyses, see Leung et al., 2022; Lozier et al., 2014; Uljarevic & Hamilton, 2013; Yeung, 2021). This seems to suggest that the internal representations used by the non-autistic people to create the expressions in the images align with the internal representations used by the non-autistic participants, but not those of the autistic participants. However, there are at least four reasons to question this conclusion.

First, there is no consensus about which emotional expressions autistic people are less accurate than non-autistic people at identifying. In their meta-analyses, Leung et al. (2022) and Yeung (2021) concluded that autistic people had more difficulty than non-autistic people in recognizing all six of the basic emotions–happiness, sadness, anger, fear, disgust, and surprise. But in their meta-analyses, Uljarevic and Hamilton (2013) concluded that autistic people did not have difficulty with happiness, and Lozier et al. (2014) concluded that they did not have difficulty with happiness, sadness, or surprise. If autistic and non-autistic people did have different internal representations for what some or all emotions look like, one would expect consistency in which emotions autistic people have difficulty with.

Second, three of the four meta-analyses found evidence that null results–those that would suggest no difference between autistic and non-autistic people's internal representations–were likely underrepresented in the data (Leung et al., 2022; Uljarevic & Hamilton, 2013; Yeung 2021). That is, it is possible that at least some studies failed to find a difference in emotion recognition accuracy between autistic and non-autistic people, but because of the bias against studies lacking significant effects (Hubbard & Armstrong, 1998), these studies were not published. The three meta-analyses concluded that autistic people are likely to have more difficulty with emotion recognition than non-autistic people, but Uljarevic and Hamilton (2013) argued that reported effects likely overestimate the true difference.

Third, across the studies reported in the meta-analyses, different methodologies are used, which can lead individual studies to competing conclusions regarding whether autistic people have difficulty with recognizing emotions. For example, in their meta-analysis, Leung et al. (2022) found that autistic people had difficulty with emotion recognition tasks that required verbal responses, but not those that required non-verbal responses. For example, on tasks that required participants to select which of six or more emotion words described a face, autistic participants were less accurate compared to non-autistic participants (e.g., Couture et al., 2010; Eack et al., 2015; Kliemann et al., 2012; Otsuka et al., 2017). But on tasks where participants could respond by matching expressions, rather than by responding via written or spoken words, the accuracy of autistic and non-autistic participants did not differ (e.g., Isomura et al. 2014).

In another example, when participants had to indicate if a face was happy or sad, angry or disgusted, afraid or surprised, and so on, autistic children responded less accurately than non-autistic children when their responses were time-limited (Nagy et al., 2021). But when responses were not time-limited, there was no difference between autistic and non-autistic participants.

Thus, some task demands may make it appear that the two neurotypes have different internal representations, even if they do not.

Finally, studies on emotion recognition in autistic participants have generally not considered the effects of alexithymia. Alexithymia is a subclinical condition, referring to difficulty identifying or describing one's own emotions (Bagby et al., 1994; Nemiah & Sifneos, 1970). Individuals with high levels of trait alexithymia have a difficult time with facial emotion recognition as a result of their difficulty recognizing their *own* emotional experiences (e.g., Grynberg et al., 2012; Jongen et al., 2014; Lane et al., 1996). Interestingly, autistic people have higher levels of alexithymia than do non-autistic people (Berthoz & Hill, 2005; Hill et al., 2004; Lombardo et al., 2007; Milosavljevic et al., 2016). Because of the overlap between autism and alexithymia and given the difficulties with emotion recognition for alexithymic people, the difficulty with emotion recognition often presumed to be associated with autism may actually be caused by high levels of alexithymia (Bird & Cook, 2013).

Indeed, several studies have found that when autistic and non-autistic samples are matched on trait alexithymia, group differences in emotion recognition disappear (e.g., Bird et al., 2010; Cook et al., 2013; Ketelaars et al., 2016; see Sivathasan et al., 2020 for a review). For example, a sample of autistic and non-autistic adults matched on level of alexithymia performed similarly to one another on a standard emotion recognition task (Cook et al., 2013). Likewise, after controlling for level of alexithymia, autistic and non-autistic adults did not differ in activation of the left anterior insula in response to viewing images of others expressing pain (Bird et al., 2010). Together, these kinds of findings suggest that being autistic on its own may not be an explanation for the robust differences in autistic and non-autistic people's performance on emotion recognition tasks. Given that it is not clear whether autistic people are less accurate at recognizing emotions (on non-autistic faces), it seems premature to conclude that the two neurotypes have different internal representations of emotion.

Non-Autistic People's Recognition of Autistic People's Expressions

A different and less common method of comparing autistic and non-autistic people's internal representations for emotional expressions is to ask how well non-autistic people recognize emotions on autistic and non-autistic faces. To my knowledge, only two studies have directly applied this methodology, and they have come to different conclusions. In Faso et al. (2015), autistic and non-autistic people posed for photos as they made happy, sad, angry, fearful, and neutral faces. These images were then presented to 38 non-autistic participants, who had to select which emotion each face showed. Faso et al. reported that the non-autistic participants were *better* at recognizing autistic than non-autistic emotional expressions.

This finding initially seems to reflect what I earlier described as an unlikely pattern, in which members of Group A recognize expressions produced by members of Group B better than other members of Group A. But as Faso et al. (2015) explain, their main effect of neurotype was primarily driven by differences in recognition for one emotion. Indeed, as reported in their Table 2 (averaged over the two levels of expression intensity they used) anger was recognized much more accurately on autistic than non-autistic faces (~67% vs. ~41% accuracy, respectively), but there were minimal differences in recognition accuracy between the autistic and non-autistic faces for sadness (~65% vs. ~60%) and fear (~50% vs. ~50%), and non-autistic expressions of happiness were recognized more accurately (~97%) than the autistic expressions (~81%). Faso et al.'s (2015) final conclusion was not that non-autistic people recognize emotion better on autistic than non-autistic faces, but that non-autistic people do not seem to have difficulty identifying autistic people's facial emotional expressions.

On the other hand, the only other study of which I am aware that has compared how well non-autistic participants recognize autistic and non-autistic expressions came to a different conclusion (Brewer et al., 2016). In this study, autistic and non-autistic people were asked to make expressions depicting six emotional states (anger, disgust, fear, happiness, sadness, and surprise), and non-autistic participants[2] were asked to choose which of six emotions were depicted in the images. The average recognition score, collapsing across the six emotions, was lower for the autistic faces than the non-autistic faces, an effect that Brewer et al. concluded was "seemingly due to [autistic people's] atypical representations of emotion" (p. 270). By this account, the autistic models' different internal representations led them to produce emotional expressions that were recognized with less accuracy by the non-autistic participants.

Here too, however, there is reason to believe that the effect was driven by one emotion. Indeed, close inspection of Brewer et al.'s (2016) data (their Table 1, "standard condition") suggests that only for happiness were non-autistic expressions better recognized than autistic expressions (88% vs. 67% accuracy, respectively). There were minimal differences in how well participants recognized non-autistic and autistic expressions for the other five emotions: surprise (44% vs. 46%), disgust (53% vs. 51%), anger (57% vs. 51%), sadness (44% vs. 52%) and fear (28% vs. 36%). This mixed pattern of results presents the same problem as in Faso et al., (2015), making it impossible to conclude from these data whether autistic and non-autistic people share internal representations for emotions or not.

As with the confusing literature described in the previous section on autistic and non-autistic people's recognition of non-autistic emotional expressions, the conflicting findings

[2] Brewer et al. (2016) also included a sample of autistic participants in the study, who also recognized the emotions produced by autistic people less accurately than the emotions expressed by non-autistic people, a finding Brewer et al. attributed to autistic people having "idiosyncratic" representations of emotion. But, because my interest is in non-autistic people's recognition for autistic and non-autistic emotions, I focus only on those data in this description.

between Faso et al. (2015) and Brewer et al. (2016) are also difficult to reconcile because of several methodological differences. First, although both studies provided similar instructions to the individuals posing for photographs, the number of individuals photographed differed (16 autistic and 17 non-autistic posers in Brewer et al., and 6 autistic and 6 non-autistic posers in Faso et al.). Second, Brewer et al.'s conclusions are based on responses to six emotions, while Faso et al.'s are based on only four. Third, Brewer et al. presented stimuli to participants for 800 ms, while in Faso et al., participants could view the stimuli for as long as they needed to make a response. Fourth, Brewer et al.'s study included only 13 non-autistic participants (some of whom had also served as models in the photographic stimuli), while Faso et al. included 38 non-autistic participants. Thus, whether differences in internal representations may contribute to why non-autistic people have difficulty understanding autistic people's emotions remains an open question.

In the five studies reported in this dissertation, I compared non-autistic adults' recognition of autistic people's emotional expressions to their recognition of non-autistic people's expressions. Study 1 investigates how well a large sample of non-autistic participants ($N = 371$) recognized the expressions in Brewer et al.'s (2016) "standard" condition. Study 2 ($N = 159$) compares recognition accuracy for autistic and non-autistic faces when participants have 800 ms to view a given stimulus (as in Brewer et al., 2016) vs. an unlimited amount of time (as in Study 1 and in Faso et al., 2015). Study 3 ($N = 166$) investigates the components of the autistic and non-autistic facial expressions that led to their being accurately recognized in Studies 1 and 2. Study 4 ($N = 148$) tests whether the context in which the posed emotional expressions were produced had an effect on how non-autistic participants perceived those expressions. Finally, Study 5 ($N = 344$) tests whether the context in which the posed emotional expressions were produced had an effect on how accurately they were recognized.

Study 1- Do Non-Autistic People Recognize Autistic People's Expressions Better Than Non-Autistic People's?

To investigate whether autistic and non-autistic people share internal representations for emotional expressions, I conducted a study similar to the ones reported in Brewer et al. (2016) and Faso et al. (2015): Non-autistic participants were shown photos of autistic and non-autistic individuals posing in six emotional expressions, and they made forced-choice judgments about which of the six emotions was shown on each face. I used the same stimuli as in Brewer et al.'s "standard" condition.

There are four important points to consider regarding Study 1's design. First, like Faso et al. (2015) but unlike Brewer et al. (2016), I included only non-autistic participants. Although I would ideally have additionally included a sample of autistic participants (as Brewer et al. did), I did not have access to a sufficient number of them. However, my interest was in understanding why non-autistic people misunderstand autistic people's emotions. As such, using a sample of non-autistic participants is sufficient, I argue, to begin to address questions about whether autistic and non-autistic people share internal representations for emotional expressions.

Second, I used only one of the three sets of stimuli created by Brewer et al. (2016). Brewer et al. photographed autistic and non-autistic posers in three conditions, one where posers were told to express an emotion to the best of their ability ("standard"), another where posers were told to make expressions that could be guessed by the person taking the photo ("communicate"), and one where the poser could see their face as they assumed the desired expression ("mirror"). In this study, I used only the images from the standard condition. In discussions with Brewer and Bird (the first and senior authors, respectively, on the Brewer et al., 2016 publication) prior to conducting Study 1, they suggested that images from the standard condition were most like those that might be observed in real life, and thus most likely to be representative of real-world interactions. (Studies 2 and 3 also use stimuli from the standard condition, while Studies 4 and 5 use stimuli from both the standard and the communicate conditions.)

Third, I did not limit the amount of time observers could view the image before deciding what emotion the face was conveying. Brewer et al. (2016) had limited the stimulus presentation time to 800 ms. This difference in timing was inadvertent (and discovered only after Study 1 was completed). Study 2 investigates directly whether the length of time participants can see an image has an effect on emotion recognition accuracy. (To foreshadow results from Study 2, it does not.)

Finally, whereas Faso et al. (2015) and Brewer et al. (2016) had small sample sizes (N = 38 and N = 13, respectively), in Study 1, I included 371 non-autistic participants.

Method

Participants

Participants were 371 non-autistic individuals from the University of Virginia, who participated for course credit. Data from 37 additional participants were collected, but their data are not reported here because they self-identified as autistic (and this study was intended to include only non-autistic participants) (5); because they failed to respond to all trials (29); or because they completed what was intended to be a 60-minute study in less than 15 minutes, suggesting they had not sufficiently attended to the task (3). I did not conduct an a priori power analysis; the study was available from November 2020 to December 2020, and I allowed any student registered with the participant pool to take it.[3]

[3] After data collection was completed, I conducted a power analysis using G*Power (Erdfelder et al., 1996; Faul et al., 2007). It showed that for a 2 x 6 repeated measures ANOVA (the format of my analysis, described below),

Participant demographics are reported in Table 1, but briefly: the sample was, on average, 19 years old (M_{age} = 18.95, SD_{age} = 1.41, *Range* = 18-32 years old), and most participants identified as female (70%) and White (64%).

Table 1.

Study 1 Participant Demographics

	Female	Male	Non-Binary
N (%, N)	70% (258)	30 % (111)	1% (2)
Age (Mean, SD)	18.86 (1.36)	19.16 (1.50)	19.5 (0.71)
Race/Ethnicity (%, N)			
African American	5% (12)	4% (4)	-
Asian American	20% (52)	21% (23)	-
Hispanic/Latinx	2% (5)	2% (2)	50% (1)
White	64% (165)	66% (73)	-
Multiple Races	8% (20)	6% (7)	50% (1)
Other	2% (4)	1% (1)	-
Decline to Answer	-	1% (1)	-

Note. Percentages reported in all demographic tables are of the total number of participants within that gender identity, not percentage of the whole sample. Percentages are rounded to the nearest whole number.

detecting a small effect of Cohen's F = 0.1 with .95 power would require 166 participants. This suggests that the sample size of 371 was more than sufficiently powered to detect small to large effects, should they exist.

Stimuli

Stimuli were those used in Brewer et al.'s (2016) standard condition. Autistic and non-autistic posers were given pieces of paper with one of six emotion terms written on it (anger, fear, disgust, happiness, sadness, and surprise). Posers were instructed to make the facial expression associated with that emotion for three seconds and were photographed as they did so (Brewer et al., 2016, p. 264). The order in which they made the expressions was random. Photos were black and white.

Although Brewer et al. (2016) used photos from 16 autistic and 17 non-autistic posers, they were able to share complete sets of photos of all six expressions for 12 non-autistic (all male) and 12 autistic posers (9 male, 3 female[4]). Thus, I presented participants with 144 photos, 72 of which were of non-autistic posers and 72 of which were of autistic posers. Figure 1 shows an example of one non-autistic poser's complete set of expressions.

[4] Because there were unequal numbers of male and female posers in these two groups, I also investigated whether there were gender-based effects in these results. All analyses from Studies 1-5 that compared autistic and non-autistic posers were also completed with only the male posers. Patterns and interpretation of results reported with all posers were generally the same those with just the male posers, and so I do not return to consideration of this topic. All relevant statistics can be found in Appendix E.

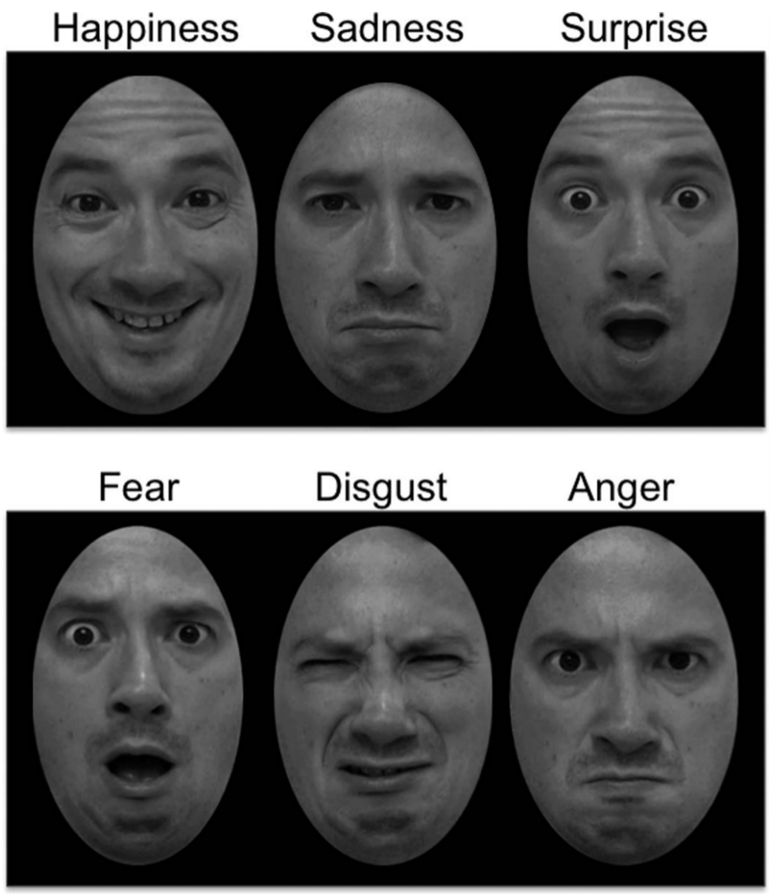

Figure 1. One non-autistic poser's set of six expressions created in the standard condition of Brewer et al. (2016) and used in Studies 1-5. This image was originally included in the Brewer et al. (2016) publication.

Procedure

Participants completed the study on Qualtrics, an online survey platform. After completing consent and demographic forms, participants began the study. The 144 faces described above were presented to participants one at a time and in a random order, and participants selected which of six emotions the face showed (see Figure 2 for an example). For each trial, the stimulus remained visible until they selected an emotion and clicked an arrow to proceed to the next trial.[5]

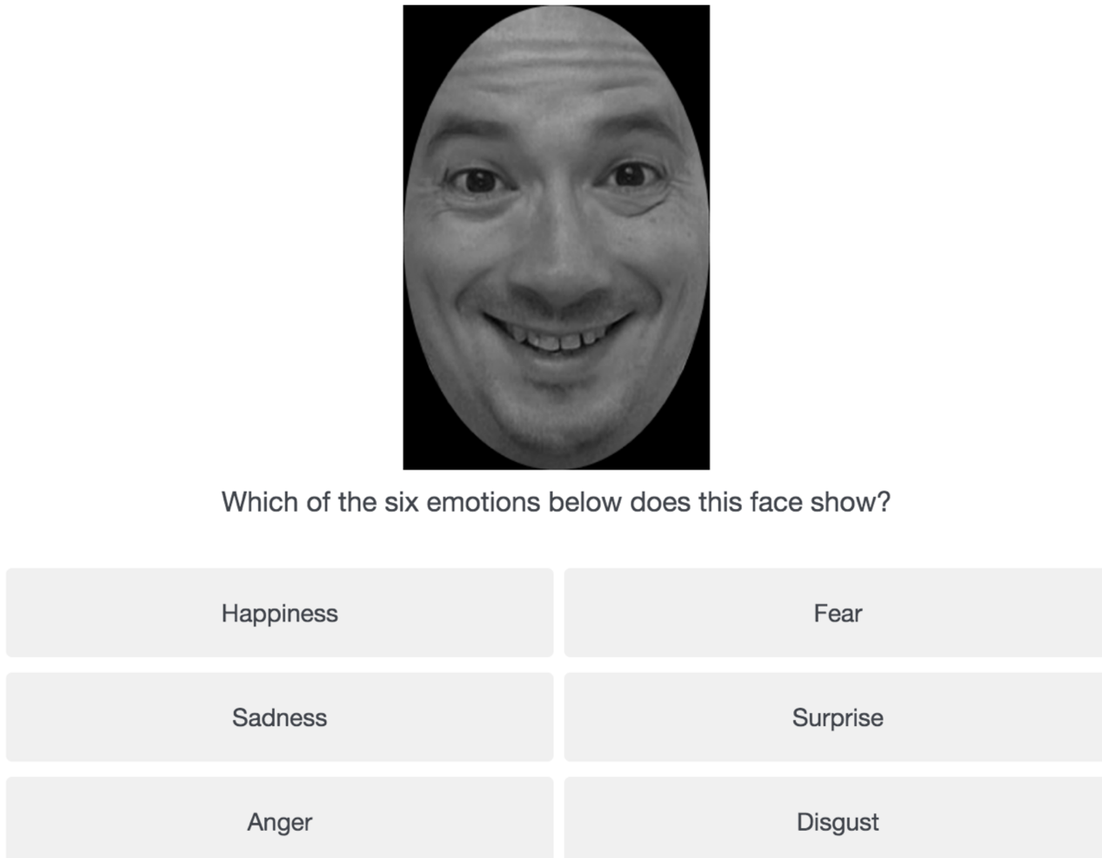

Figure 2. An example of one trial of the emotion recognition paradigm used in Studies 1, 2, and 5. Response options appeared in the same order for all trials, all participants, and across all studies.

[5] I had initially considered the possibility that if participants made an incorrect decision initially, their performance might improve if given a chance to make a second response. Therefore, after each initial response and regardless of whether it was correct, participants were prompted with the face again and told to select from the remaining five labels what other emotion it could be (or they could also select "none"). Here I report only the results from the initial responses as they are more comparable to the procedure used by both Brewer et al. (2016) and Faso et al. (2015). Results from the second attempt analyses can be found in Appendix A.

Analysis Plan

Data for all studies reported in this dissertation were analyzed with R (version 4.2.1; R Core Team, 2022), using the RStudio interface (version 2022.07.2+576; posit, 2022). In studies that include an emotion recognition paradigm (Studies 1, 2, and 5) I will report analyses from two dependent variables generated from participants' responses. The first is a traditional emotion recognition accuracy score, which is the proportion of expressions correctly identified, relative to the entire number of expressions. The second is a Wagner's Unbiased Hit Rate score (Wagner's UHR; Wagner, 1993), which accounts for any bias in participant's responses introduced by a tendency to select one response option more frequently than others. In the analyses that follow, I will present the results regarding the emotion recognition accuracy score, as this is the dependent variable reported by both Brewer et al. (2016) and Faso et al. (2015). I will then briefly present the results of the Wagner's UHR analyses.

Both emotion recognition accuracy and Wagner's UHR were analyzed using mixed effects modelling with the "lme4" package in R (Bates et al., 2015). In these models, the independent variables of poser neurotype (two levels: autistic or non-autistic), emotion (six levels: anger, disgust, fear, happiness, sadness, and surprise), and their interaction were treated as fixed effects. To account for multiple observations, a random effects term estimated an intercept for each participant.

Given Brewer et al.'s (2016) findings using the same stimuli, I expected that non-autistic posers' expressions would be better identified than autistic posers' expressions, which would be evident by a main effect of poser neurotype. I additionally expected that some emotions would be identified better than others, and that the magnitude of the differences between emotions might vary by poser neurotype, which would be evident in a main effect of emotion and/or an interaction between poser neurotype and emotion. To follow up on any of these main or interaction effects, I used the "emmeans" package in R (Lenth, 2022). Data and code for this study can be found at https://osf.io/jwt8a.

Results

Emotion Recognition Accuracy

Figure 3 shows the average emotion recognition accuracy score as a function of emotion and poser neurotype. As shown in the Figure, for all emotions but happiness, recognition accuracy for expressions produced by autistic posers was higher than those for expressions produced by non-autistic posers, $F(1, 4070) = 296.39$, $p < .001$. Some emotions were identified better than others, $F(5, 4070) = 1649.12$, $p < .001$, and there was an interaction between poser neurotype and emotion $F(5, 4070) = 18.79$, $p < .001$.

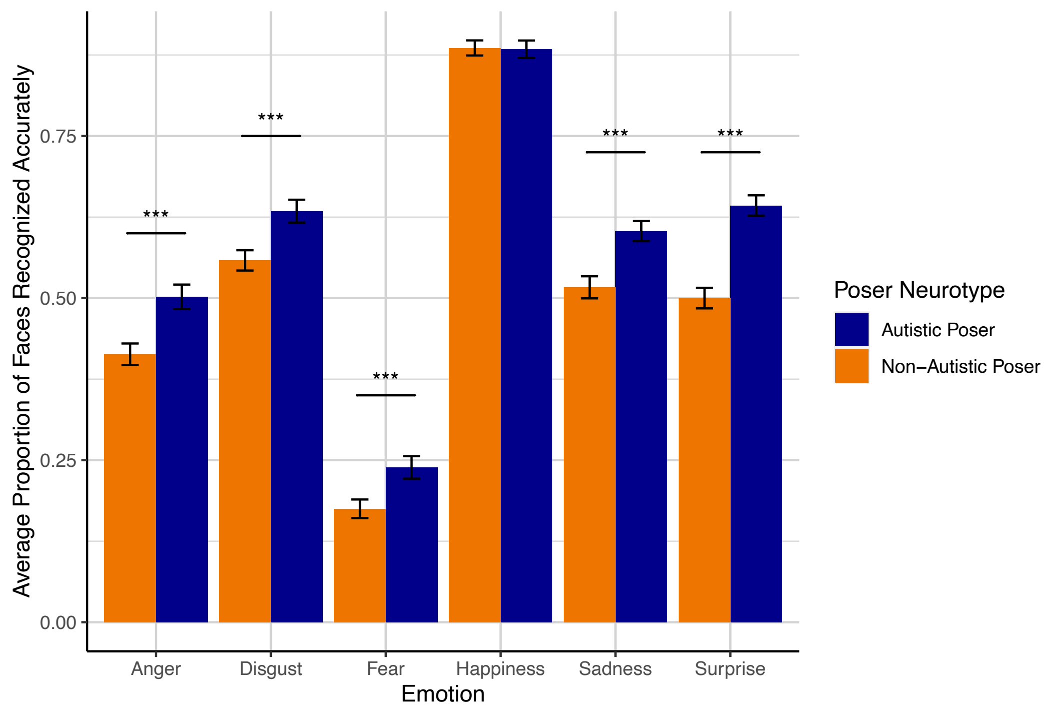

Figure 3. Study 1 average emotion recognition accuracy as a function of poser neurotype and emotion. Error bars represent the 95% confidence interval. Asterisks indicate whether recognition of autistic and non-autistic posers differed. *** $p < .001$.

To follow up on the two-way interaction between poser neurotype and emotion, I compared the average recognition accuracy score between autistic and non-autistic expressions separately for each emotion. For all emotions but happiness, autistic expressions were recognized significantly better than non-autistic expressions, all *t*s (4070) ≥ 5.90, all *p*s < .001. There was no difference in recognition rates between autistic and non-autistic expressions for happiness, $t(4070) = -0.19$, $p = .841$ (see Table A2 in Appendix A for full inferential statistics).

Poser Rank

It is possible that the autistic expressions were better recognized because of a small subset of autistic posers who produced particularly recognizable expressions. To investigate this possibility, I calculated each poser's rank within a given emotion category. Figure 4 shows each poser's emotion recognition accuracy rank (relative to the other posers) as a function of emotion and poser neurotype (i.e., each line represents a single poser). If higher emotion recognition accuracy were being driven by a subset of particularly expressive autistic posers, there would be several relatively stable lines from that group across the top of the figure. Instead, as the figure shows, which posers were best recognized depended on the emotion depicted, and this was true of both the autistic and non-autistic posers. Indeed, none of the correlations for the posers ranks for any of the pairs of emotions was ≥ |.50| suggesting that, as the figure shows, there was no particularly recognizable poser's face (see Table A3 in Appendix A for full correlation matrix).

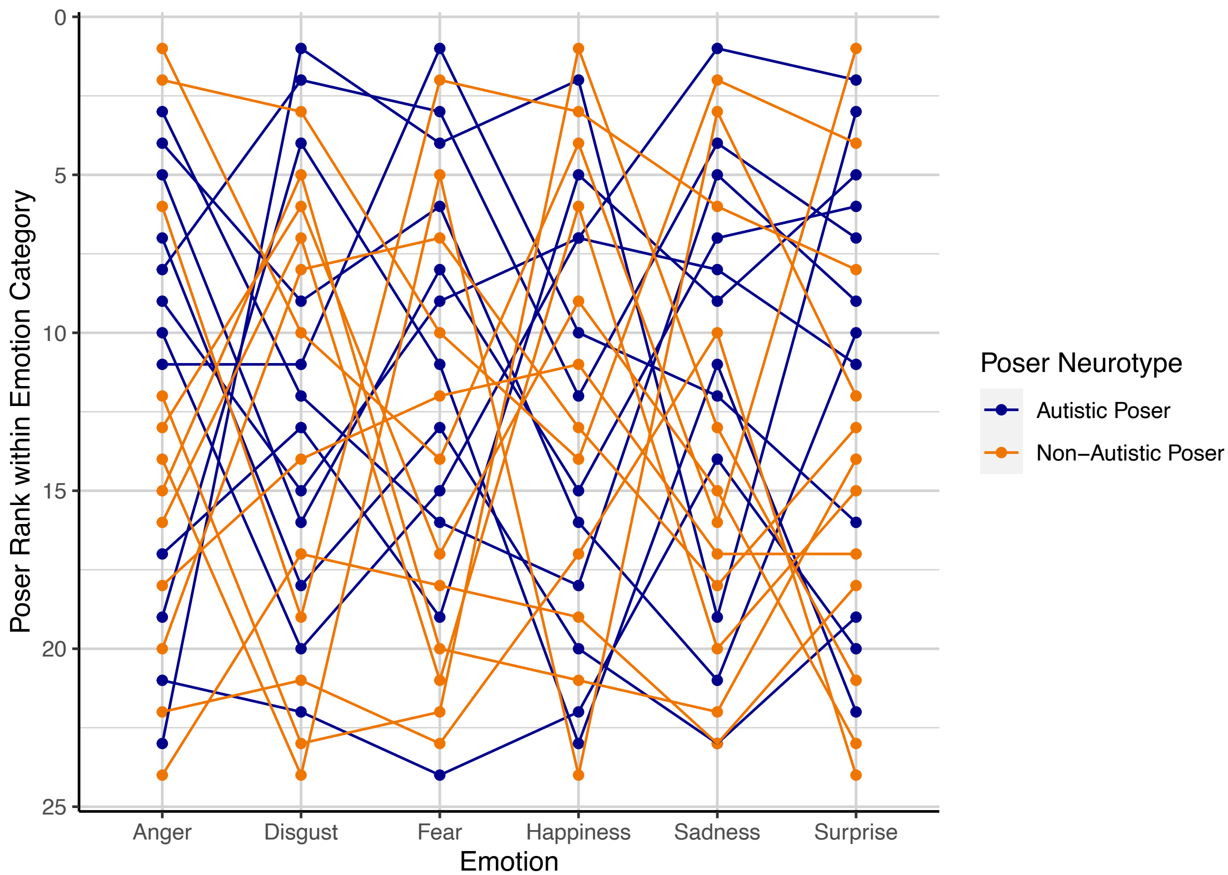

Figure 4. Study 1 poser rank as a function of emotion and poser neurotype. Each point represents a given poser's rank within that emotion category. Lines connect the same poser across the six emotion categories. Lower rank indicates higher average recognition accuracy for that poser relative to the other posers (i.e., a rank of 1 indicates highest recognition accuracy amongst both autistic and non-autistic posers, a rank of 24 indicates lowest recognition accuracy).

Wagner's UHR

I conducted an identical analysis modelling participants' responses with Wagner's UHR as the dependent variable. The results of this analysis revealed significant main effects of poser neurotype, $F(1, 4045.9) = 792.89$, $p < .001$, emotion, $F(5, 4045.7) = 3500.59$, $p < .001$, and a significant two-way interaction between poser neurotype and emotion $F(5, 4045.8) = 28.86$, $p < .001$. To follow up on this two-way interaction, I investigated the simple effect of poser neurotype at each level of emotion. For every emotion, autistic expressions were recognized with greater accuracy than non-autistic expressions, all *t*s $(4045) \geq 2.50$, all *p*s $< .05$ (see Table A4 in Appendix A for all pairwise comparisons). Thus, for both emotion recognition accuracy and Wagner's UHR, autistic expressions were recognized more accurately than non-autistic expressions.

Discussion

Contrary to my expectations, expressions produced by autistic posers were recognized more accurately, on average, than expressions produced by non-autistic posers (except for happiness, where there was no difference). That a sample of non-autistic participants recognized the expressions of autistic posers more accurately is incompatible with the hypothesis that differences in internal representations are to blame when a non-autistic person misunderstands an autistic person's emotions in real interactions.

My results in Study 1 differ from those of Brewer et al. (2016)—whose stimuli I used—who found that non-autistic participants tended to recognize expressions produced by non-autistic posers with greater accuracy. Interestingly, my findings also differ somewhat from those of Faso et al. (2015). While Faso et al. found an advantage in recognition accuracy for autistic posers, this effect was driven by greater accuracy for autistic expressions of anger. In Study 1, I found an advantage for autistic expressions in all emotions but happiness.

There are two possible explanations for why results from Study 1 differ from those of Brewer et al. (2016) and Faso et al. (2015). First, my Study 1 had 371 non-autistic participants, a sample much larger than either Brewer et al. (2016; $N = 13$) or Faso et al. (2015; $N = 38$).

Second, like Faso et al.—who also found an advantage in recognition accuracy for autistic expressions—Study 1 did not limit participants' exposure to the stimuli prior to their responses. But Brewer et al.—who did not find an advantage for autistic expressions—limited participants' exposure to the stimuli to 800 ms. While I suspect that the sample size explanation is the most likely, it is important to experimentally investigate whether the duration of stimulus presentation time has a differential effect on recognition accuracy for autistic and non-autistic expressions. This was the goal of Study 2.

Study 2- Does Length of Stimulus Exposure Explain Study 1's Surprising Results?

The difference in stimulus duration is an unlikely explanation for the discrepancy between results of Study 1 and those of Brewer et al. (2016). While Brewer et al. (2016) did limit participants' exposure to the stimuli to 800 ms, prior research suggests that this limited exposure should not have an impact on emotion recognition accuracy. For example, work investigating response times to emotional stimuli has found that people tend to make a decision about what emotion a face is showing in less than 1000 ms (e.g., Markovska-Simoska & Pop-Jordanova et al., 2010; Sonneville et al., 2002; Tracy et al., 2011; Tracy & Robins, 2008). Similarly, work investigating duration-limited stimuli has found that emotion recognition accuracy is still high (i.e., >70% accuracy) for stimuli presented for even 500 ms or less (e.g., Calvo et al., 2008; Getz et al., 2003; Tseng et al., 2017). As such, it is not likely that limiting participants' exposure to 800 ms would have an effect on emotion recognition accuracy. Nevertheless, to test the effect of stimulus duration, participants completed the same task as in Study 1, either in an untimed condition (an exact replication of Study 1) or in a timed condition. In the timed condition, each stimulus was visible to participants for 800 ms, after which it was replaced by the six response options.

Another important factor to consider is that participants' performance on emotion recognition tasks can be influenced by the extent to which they experience traits associated with autism. The concept of the broad autism phenotype captures the idea that non-autistic people vary in the extent to which they experience traits associated with autism (Piven et al., 1997). This means that the non-autistic participants in this sample also experienced a varying degree of autistic traits. Prior work has found that higher levels of autistic traits (in non-autistic people) are associated with worse performance on emotion recognition accuracy tasks (e.g., Bölte &

Poustka, 2003; Evers et al., 2015; Kadak et al., 2014; Palermo et al., 2006; Sucksmith et al., 2013). To account for any differences in emotion recognition performance, participants in Study 2 (and in Study 5, the remaining two studies that included emotion recognition tasks) completed the Broad Autism Phenotype Questionnaire (BAP-Q; Hurley et al., 2007), and scores on the BAP-Q were included as a covariate in emotion recognition analyses in those studies.

Method

Participants

Participants were 159 non-autistic undergraduates or recent graduates of the University of Virginia. Data from an additional 11 participants were collected, but they are not reported here because they did not finish the study (4), or because they identified as autistic (7). Data were collected from July to September 2022[6]. Eighty-two percent of participants (N = 130) participated in exchange for compensation in the form of a $7.50 Amazon™ gift card. The remaining participants (N = 29) participated in exchange for course credit. The results reported below were the same when I included the full sample or when I included only those participants who completed the study for compensation.

Full participant demographics are reported in Table 2. The sample was on average 20 years old (M_{age} = 20.03, SD_{age} = 1.35, *Range* = 18-28 years old), and most participants identified as female (87%) and White (59%).

Prior to data collection, I conducted an a priori power analysis using the "simr" package in R (Green & MacLeod, 2016). This power analysis indicated that to detect an overall reduction in emotion recognition accuracy of 7.5% between participants in the timed and untimed condition would require 150 participants (75 per condition). I chose 7.5% as the minimum effect

[6] Note that Study 2 took place after Studies 3 and 4, but here is presented as the second study in this dissertation.

size of interest because it is the average difference (rounded to one half of a percent) in recognition accuracy between autistic and non-autistic expressions in Study 1 ($M_{Difference}$ = 7.33%) In the final sample of 159 participants, 80 were in the timed condition and 79 were in the untimed condition, both described below.

Table 2.

Study 2 Participant Demographics

	Female	Male	Non-Binary
N (%, N)	87% (139)	11% (18)	1% (2)
Age (Mean, SD)	20.05 (1.40)	19.89 (1.02)	20.00 (1.41)
Race (%, N)			
African American	9% (13)	6% (1)	-
Asian American	26% (36)	22% (4)	-
White	58% (81)	67% (12)	50% (1)
Multiple Races	6% (8)	6% (1)	-
Other	1% (1)	-	50% (1)
Ethnicity			
Hispanic/Latinx	7% (9)	6% (1)	-
Non-Hispanic/Latinx	90% (125)	89% (16)	100% (2)
Unknown/Decline to Answer	4% (5)	6% (1)	-

Stimuli

Stimuli were the same as those used in Study 1.

Procedure

Participants completed the study online via Qualtrics. After completing the consent form and demographics questions, participants were randomly assigned to either the timed or untimed stimulus conditions. The untimed condition was a direct replication of Study 1. In the timed condition, participants saw all 144 images one at a time and in a random order. On each trial, participants first saw a fixation cross in the center of their screen for 500 ms. The target expression replaced the fixation cross and was visible for 800 ms. After the face disappeared from the screen, participants were prompted to select which of 6 emotions they believed the expression was conveying, as in Study 1 (see Figure 1).

Broad Autism Phenotype Questionnaire (BAP-Q; Hurley et al., 2007)

Participants then completed the BAP-Q. The BAP-Q is a 36-item questionnaire designed to capture the extent to which participants endorse behavioral traits that are commonly associated with the broad autism phenotype (Piven et al., 1997). Items include prompts such as "I can tell when it is time to change topics in conversation" or "I have been told that I talk too much about certain topics." Participants respond to items via a 6-item Likert scale ranging from "*Very Rarely*" to "*Very Often*." The BAP-Q has been found to have high internal consistency (*Cronbach's* $\alpha = 0.95$; Hurley et al., 2007), and the same was true in the sample reported here (*Cronbach's* $\alpha = 0.87$, 95% CI [0.84, 0.90]).

Analysis Plan

Dependent variables were calculated and modelled the same as in Study 1. This study was pre-registered at https://osf.io/m6srd. Data and code for this study can be found at https://osf.io/jwt8a.

Results

Emotion Recognition Accuracy

The top panel of Figure 5 shows emotion recognition accuracy (as a function of poser neurotype and emotion category) for participants in the timed condition, and the bottom panel shows the results from the untimed condition. In both conditions, and replicating the results of

Study 1, non-autistic participants recognized expressions produced by autistic posers with greater accuracy than expressions produced by non-autistic posers. Importantly, this pattern was found in both the timed and untimed conditions.

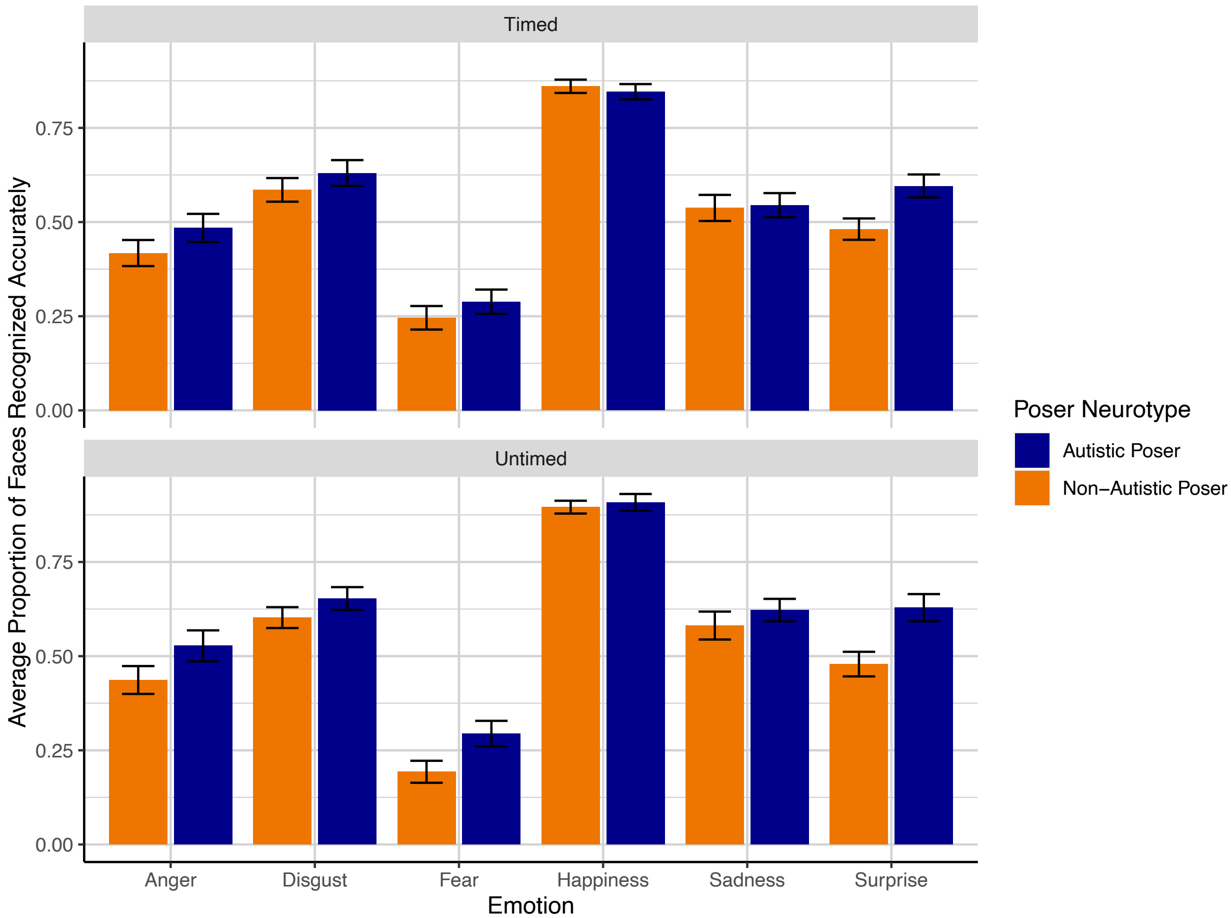

Figure 5. Study 2 average emotion recognition accuracy as a function of poser neurotype and emotion in the timed (top panel) and untimed (bottom panel) conditions. Error bars represent the 95% confidence interval. Asterisks to denote differences in pairwise comparisons of recognition accuracy are not included as the three-way interaction was not significant.

The 2 (poser neurotype) x 6 (emotion category) x 2 (timing condition) ANCOVA—with BAP-Q as a covariate—on the data in Figure 5 yielded significant main effects of poser neurotype, $F(1, 1883) = 84.18$, $p < .001$, emotion, $F(5, 1883) = 664.40$, $p < .001$, and timing condition, $F(1, 1883) = 16.98$, $p < .001$. There were also two-way interactions between poser neurotype and emotion, $F(5, 1883) = 8.75$, $p < .001$, emotion and timing condition, $F(5, 1883) = 3.51$, $p = .004$, and poser neurotype and timing condition, $F(1, 1883) = 5.74$, $p = .017$. Most importantly to the present research question, however, there was no three-way interaction between poser neurotype, emotion, and timing condition $F(5, 1883) = 0.30$, $p = .914$. This suggests that the patterns of recognition accuracy between autistic and non-autistic posers over the six emotions did not differ depending on how long participants were able to view the stimuli. Finally, the effect of the covariate, level of autism symptomatology, was also not significant $F(1, 1883) = 3.04$, $p = .081$, suggesting participants' level of autism-related traits did not affect their recognition accuracy performance.

The two-way interaction between poser neurotype and timing condition indicated that the difference in recognition accuracy between autistic and non-autistic posers was greater in the untimed than in the timed condition. Crucially, in both conditions, autistic expressions were recognized significantly more accurately than non-autistic expressions (untimed: $M_{autistic} = 60\%$ vs. $M_{non\text{-}autistic} = 53\%$, $t(1727) = 8.16$, $p < .001$; timed: $M_{autistic} = 56\%$ vs, $M_{non\text{-}autistic} = 52\%$, $t(1727) = 4.81$, $p < .001$).

Next, I investigated the simple effects between poser neurotype and emotion, averaged across the timing conditions. These simple effects revealed a pattern similar to that reported in Study 1: Autistic expressions of anger, disgust, fear, and surprise were recognized more accurately than the non-autistic expressions of those emotions (all ts ≥ 3.03, all ps $< .01$).

Happiness was recognized equally well on autistic and non-autistic faces (like Study 1), as was sadness (unlike Study 1; see Table B1 in Appendix B for all relevant statistics).

Poser Rank

Also as in Study 1, I investigated whether the patterns in recognition accuracy were being driven by a subgroup of particularly recognizable autistic posers. I calculated the relative ranking of each poser's emotion recognition accuracy score for each emotion, and within each timing condition. Figure 6 shows each poser's rank as a function of emotion, timing condition, and poser neurotype. As the figure shows, there is not a subset of consistently well recognized posers in either of the conditions. Indeed, when comparing each poser's rank across the six emotions, correlations were not greater than |.44| in either the timed or untimed conditions (see Table B2 in Appendix B for full correlation matrices). This suggests that, as in Study 1, recognition accuracy was not driven by a small subset of autistic posers.

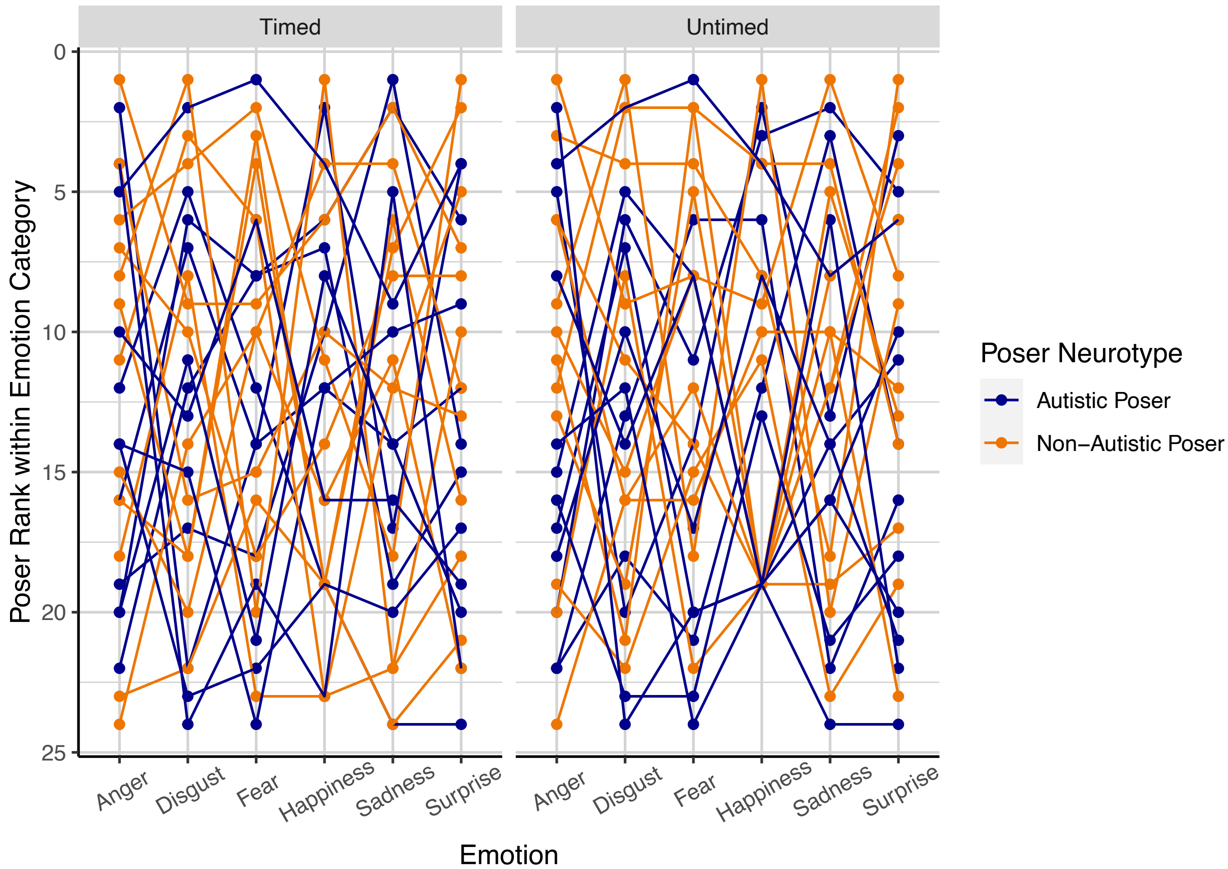

Figure 6. Study 2 poser rank as a function of emotion, timing condition, and poser neurotype. Each point represents a given poser's rank within that emotion category. Lines connect the same poser across the six emotion categories. Lower rank indicates higher average recognition accuracy for that poser relative to the other posers. Overlapping points indicate when multiple posers were tied for a given rank.

Interestingly, the relative ranking of faces was very similar in both the timed and untimed conditions. The correlation between the two was very high for each emotion: $r_{\text{Anger}} = .95$; $r_{\text{Disgust}} = .98$; $r_{\text{Fear}} = .90$; $r_{\text{Happiness}} = .85$; $r_{\text{Sadness}} = .95$; $r_{\text{Surprise}} = .98$. Therefore, participants perceived the stimuli similarly regardless of whether they were in the timed or untimed conditions.

Wagner's UHR

Last, I conducted analyses with Wagner's UHR as the dependent variable. These analyses revealed the same pattern as with emotion recognition accuracy. The effect of autism symptomatology as a covariate was not significant, $F(1, 156.2) = 3.46$, $p = .065$. The three main effects were significant: poser neurotype, $F(1, 1723.5) = 248.14$, $p < .001$, emotion, $F(5, 1723.4) = 1686.99$, $p < .001$, and timing condition $F(1, 156.1) = 17.87$, $p < .001$. The two-way interactions between poser neurotype and emotion, $F(5, 1723.5) = 9.36$, $p < .001$, emotion and timing condition $F(5, 1723.4) = 2.58$, $p = .024$, and poser neurotype and timing condition $F(1, 1723.5) = 12.38$, $p < .001$ were significant. Finally, the three-way interaction between poser neurotype, emotion, and timing condition was not significant, $F(5, 1723.5) = 0.40$, $p = .847$. The simple effects analyses stemming from the two-way interactions revealed a similar pattern of results to those analyses reported above, see Tables B3 and B4 in Appendix B for all relevant statistics. Even after accounting for potential bias in participants' responses, autistic expressions were more accurately recognized than non-autistic expressions in both the timed and untimed conditions.

Discussion

The goal of Study 2 was to determine whether the patterns of emotion recognition accuracy between autistic and non-autistic faces differed depending on how long participants could view the stimuli. I found that they do not. Regardless of whether participants had 800 ms to view a given image (as in Brewer et al., 2016) or whether they could view the image until they selected the emotion shown (as in Faso et al., 2015), non-autistic participants recognized anger, fear, disgust, and surprise more accurately on autistic expressions than on non-autistic expressions; there was no difference between autistic and non-autistic expressions for happiness or sadness. These findings replicate my initial findings in Study 1 and demonstrate that this is a robust effect.

The fact that non-autistic participants are better at recognizing many of the expressions of the autistic compared to the non-autistic posers raises the possibility that the two groups of posers have internal representations for emotional expressions that do not perfectly align. As will be described in the discussion of Study 3, I do not think this is actually the case. However, if autistic and non-autistic posers do share internal representations for emotional expressions, then one would expect that these non-autistic participants would have recognized the autistic and non-autistic expressions equally well. Since this was not the case, I suspected that there must have been some attribute of the autistic poser's internal representations that led to their creating more easily recognized expressions. Study 3 was designed to investigate what some of those attributes might be.

Study 3- Are Expressions Produced by Autistic Posers Perceived as Different from Non-Autistic Posers', and Does This Predict Recognition Accuracy?

Study 3 was designed to investigate why expressions from autistic posers were better recognized than those of non-autistic posers in Studies 1 and 2. Specifically, I asked what characteristics of the autistic compared to the non-autistic expressions led to better recognition rates. I am not the first to investigate how perceptions of autistic and non-autistic emotional expressions differ. In Faso et al. (2015), for example, participants were asked to identify the emotion shown on autistic and non-autistic faces and then to rate the "intensity" and "naturalness" of each expression. Faso et al. found that autistic people's expressions were rated as more intense but less natural, but they did not investigate the extent to which ratings of intensity and naturalness could predict accuracy of emotion expression recognition.

In Study 3, I asked a new sample of non-autistic participants to rate the stimuli used in Studies 1 and 2 on four different dimensions. First, like Faso et al. (2015), I asked participants to rate the intensity of each emotional expression. Autistic people are sometimes described as displaying flat or reduced facial affect (e.g., Stagg et al., 2014). But given that the intensity of an expression is positively associated with how accurately it is recognized (e.g., Montagne et al., 2007; Orgeta & Philips, 2007), perhaps the autistic posers in this sample made more intense emotional expressions than the non-autistic participants.

Second, I asked participants how "posed" each expression looked. I adapted this dimension from Faso et al.'s (2015) "naturalness" ratings. "Posedness" was designed to capture the idea that someone might be expressing an emotion without experiencing it. I did not have a specific hypothesis about whether one poser group would appear more or less posed than the other since the instructions given to both groups told them to "pose to the best of their ability"

(Brewer et al., 2016, p. 264). But, if either group interpreted these instructions differently, that might be captured with responses to this question.

Third, I asked participants to indicate how "awkward" an expression appeared to be. In some studies, non-autistic participants rate autistic people as more awkward than non-autistic people (e.g., Grossman, 2015; Sasson et al., 2017). I predicted that the autistic expressions would be perceived as more awkward by the non-autistic participants but did not have specific predictions regarding whether this might relate to recognition accuracy.

Finally, I asked participants to rate how "good" an example of a given emotion each expression was. I initially considered asking participants to rate the "prototypicality" of a given expression. However, I suspected that asking participants how prototypical a facial expression was could lead them to compare it to other expressions in the stimulus set, not to their own expectations for how an expression should look. This "goodness" dimension was designed to tap into whether these expressions aligned with participants' representations for emotional expressions. I assumed higher goodness ratings would be associated with a greater overlap between a given expression and a participant's expectations about the physical properties of the emotion the expression was intended to convey. Given the higher recognition accuracy described in Studies 1 and 2, I predicted that autistic faces would receive higher goodness ratings.

Finally, in Study 3, I asked whether these four characteristics of each expression could be used to predict how accurately that expression was recognized (using the emotion recognition accuracy rates in Study 1). This is important because if the expressions from autistic or non-autistic posers differ on one or more of these dimensions, then I could determine whether those differences are particularly important for predicting recognition accuracy.

Method

Participants

Participants were 166 non-autistic undergraduates at the University of Virginia, who participated for course credit. Data from 28 additional participants were collected, but their data are not reported here because they self-identified as autistic (1); because they failed to pass the attention checks described below (18); or because they completed what was designed to be a 45-minute study in less than 10 minutes (9). I did not conduct an a priori power analysis, and sample size was determined based on the number of participants available to complete the study over two weeks from late November to early December 2021.

Participant demographics are reported in Table 3, but the sample largely resembled that of Studies 1 and 2. Participants were, on average, 19 years old (M_{age} = 19.16, SD_{age} = 1.18, *Range* = 18-25 years old), mostly identified as female (61%) and White (58%).

Table 3.

Study 3 Participant Demographics

	Female	Male	Non-Binary	Self-Describe
N (%, N)	61% (101)	37 % (61)	2% (3)	1% (1)
Age (M, SD)	18.92 (1.01)	19.56 (1.35)	19.00 (1.00)	19.00 (NA)
Race (%, N)				
African American	10% (10)	7% (4)	-	-
Asian American	31% (31)	21% (13)	33% (1)	100% (1)
White	57% (58)	62% (38)	33% (1)	-
Multiple Races	1% (1)	7% (4)	33% (1)	-
Decline to Answer	1% (1)	3% (2)	-	-
Ethnicity				
Hispanic/Latinx	5% (5)	7% (4)	-	-
Non-Hispanic/Latinx	91% (92)	92% (56)	100% (3)	100% (1)
Decline to Answer	4% (4)	2% (1)	-	-

Note. The participant who indicated they preferred to self-describe their gender identity was able to provide a description via a text-response box but chose not to do so.

Stimuli

Stimuli were the same as those used in Studies 1 and 2.

Procedure

Participants completed the study on Qualtrics. Because asking participants to rate all 144 faces on 4 dimensions would have taken participants over an hour, each participant was assigned to view half of the entire stimulus set. Participants saw a pseudo-randomly selected subset of six autistic and six non-autistic posers for each of the six emotions. Each poser was seen an equal number of times across all participants. Faces were shown one at a time, in a random order.

Figure 7 shows an example of one trial. For each face, participants were told what emotion the expression was intended to convey (e.g., “This face is an expression of: Surprise”). They responded to the following four questions in this order: “How awkward is this expression of [surprise]?”, “How intense is this expression of [surprise]?”, “How much does this expression of [surprise] look posed?”, “How good is this expression of [surprise]?” Participants made their ratings on a 5-point Likert scale (*Not at all*, *Slightly*, *Mildly*, *Moderately*, and *Very*) by clicking a radio button. Participants could take as much time as they needed to make their ratings, and they could change any rating until they clicked a button to advance to the next trial. The face remained visible until they did so.

Figure 7. An example of one trial of the expression rating paradigm used in Study 3.

As an attention check, three of the 72 trials included an additional prompt asking participants to select a specific response option (e.g., “Click on ‘Not at all’”). Whether a prompt appeared before, in the middle, or after the other four ratings varied over the attention checks, as did which response option was prompted. As noted above, data from 18 participants were excluded because they failed one or more of the three attention checks they encountered. Finally, data and code for this study can be found at https://osf.io/jwt8a.

Results

Rating Clusters

Figure 8 shows the average rating for each of the four dimensions as a function of poser neurotype and across each emotion. As can be seen in the figure, the patterns of awkwardness and posedness across the six emotions largely resemble one another, as do the patterns for goodness and intensity. This suggests that these four ratings might represent two clusters of scores. To investigate this, I examined the correlations across these ratings. As expected given the figure, the highest correlation existed between the goodness and intensity ratings, r = .71, and the second highest was between the awkwardness and posedness ratings, $r = .46$. All other correlations were less than |.29|. Because these correlations suggested that the ratings clustered into two dimensions, and to avoid issues with multicollinearity in later analyses (see Chatterjee, 2012; Midi & Bagheri, 2010), I averaged awkwardness and posedness ratings to create a composite score, and goodness and intensity ratings to create a composite score[7]. The composite awkwardness/posedness and goodness/intensity scores were not correlated with each other, $r = -.07$.

[7] To confirm whether the creation of these composite scores was necessary, I also fit a model with the four ratings as separate independent predictors of recognition accuracy from Study 1. Variance inflation scores on the goodness and intensity ratings in particular indicated unacceptable levels of multicollinearity, and thus use of the composite scores was necessary. Relevant statistics can be found in Appendix C.

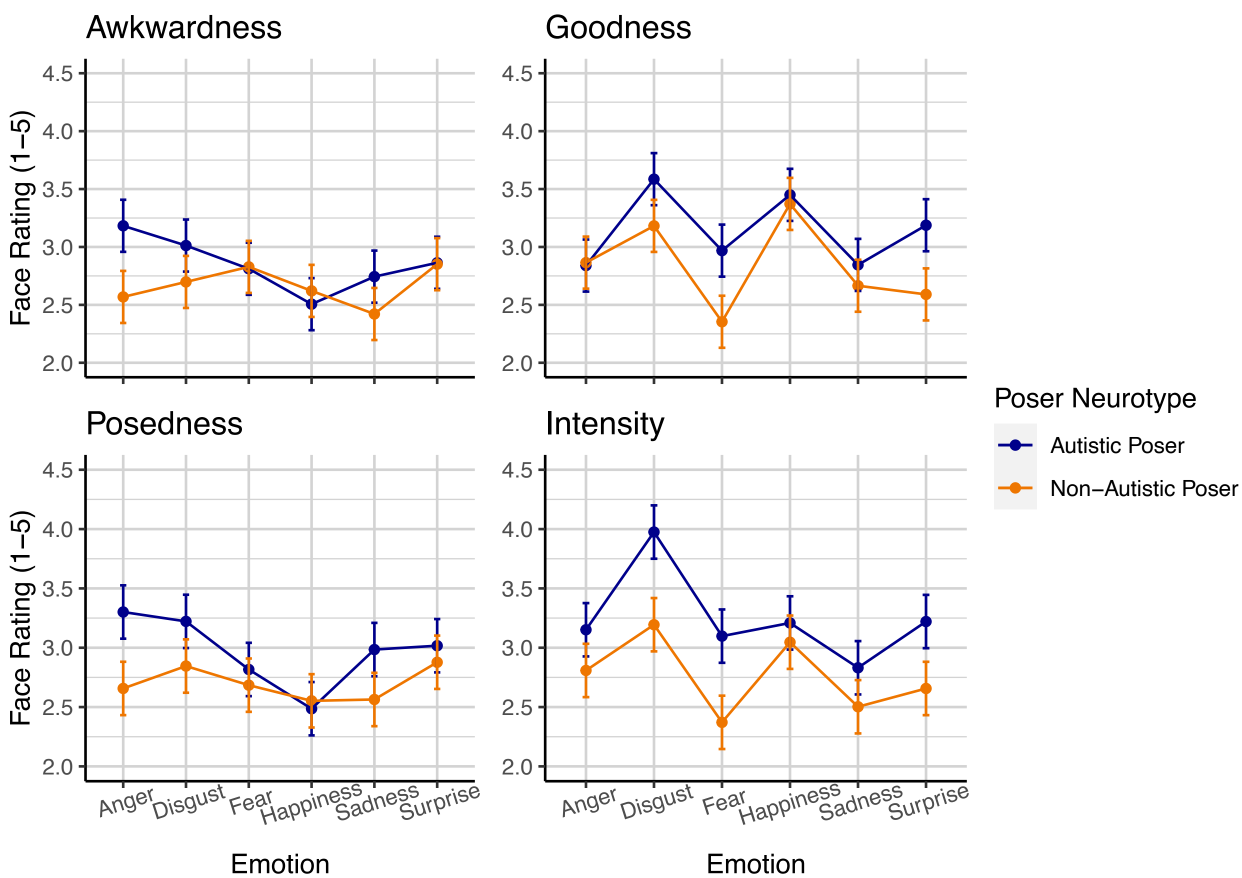

Figure 8. Study 3 average ratings for the expressions as a function of poser neurotype and emotion for each of the four original rating dimensions. Error bars represent the 95% confidence interval.

Group Level Differences in Composite Ratings

Figure 9 shows the average ratings for the awkwardness/posedness and goodness/intensity composites as a function of poser neurotype and emotion. As the figure shows, for anger, disgust, and sadness, expressions from autistic posers were rated as more awkward/posed than expressions from non-autistic posers. For disgust, fear, and surprise, expressions from autistic posers were rated as better/more intense than expressions from non-autistic posers.

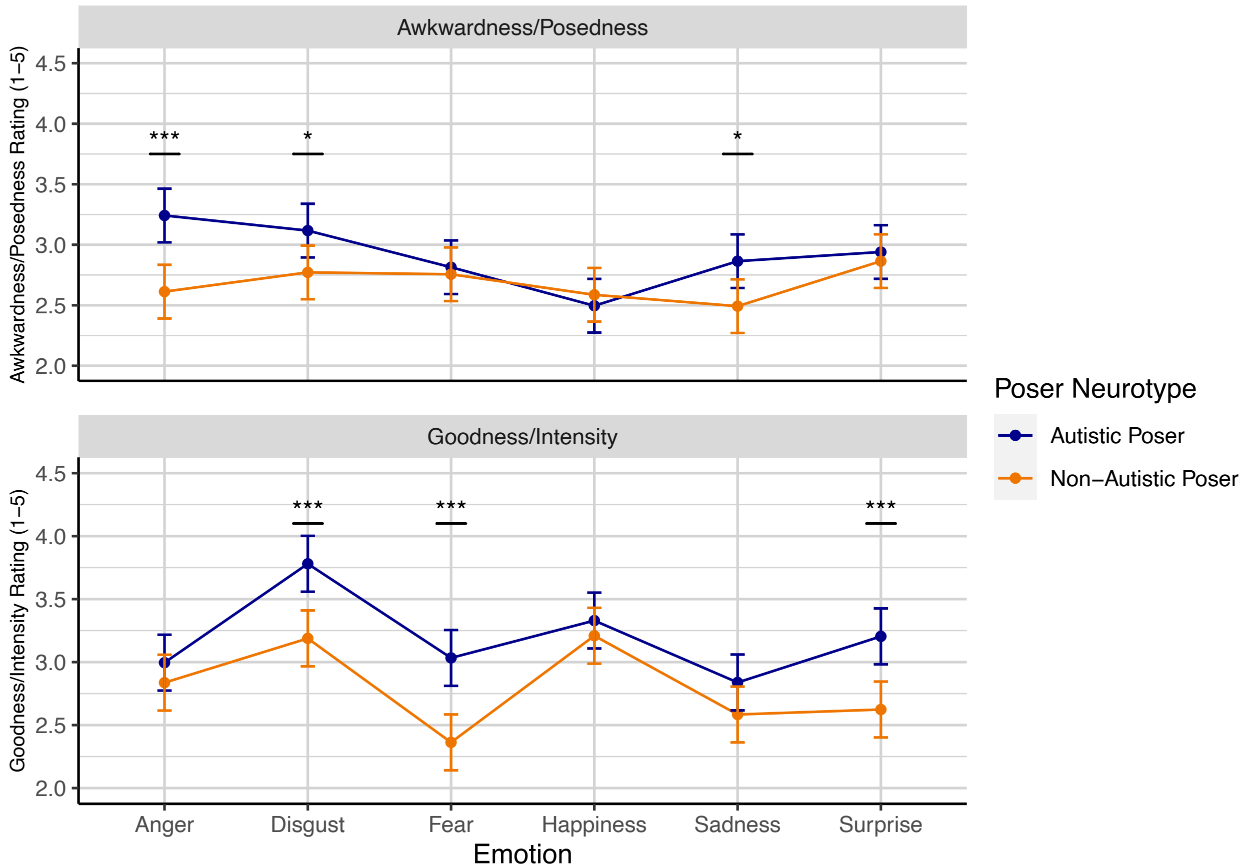

Figure 9. Study 3 average composite score for the expressions after consolidating the four rating dimensions into two composites: awkwardness/posedness (top panel) and goodness/intensity (bottom panel). In both panels, error bars represent the 95% confidence interval. Asterisks indicate whether ratings for autistic and non-autistic expressions differed from each other for a given emotion. *$p < .05$, *** $p < .001$.

To investigate whether the autistic and non-autistic expressions received different ratings on these dimensions, I conducted a 2 (poser neurotype) x 6 (emotion) x 2 (rating composite) ANOVA. The ANOVA revealed a three-way interaction between poser neurotype, composite, and emotion, $F(5, 23693) = 36.39$, $p < .001$. To follow-up on this three-way interaction, I conducted simple effects analyses investigating the two-way interaction between poser neurotype and emotion for each composite separately. For the awkwardness/posedness composite, the two-way interaction between poser neurotype and emotion was significant, $F(5, 23693.09) = 31.40$, $p < .001$: Expressions produced by autistic posers received higher awkwardness/posedness scores than those produced by non-autistic posers when expressing anger, disgust, and sadness. There was no difference in awkwardness/posedness scores between autistic and non-autistic expressions of fear, happiness, and surprise (see Table 4).

For the goodness/intensity composite, the two-way interaction between poser neurotype and emotion was statistically significant $F(5, 23693.09) = 27.04$, $p < .001$. Expressions produced by autistic posers received higher goodness/intensity scores than those produced by non-autistic posers when expressing disgust, fear, and surprise. There was no difference in goodness/intensity scores between autistic and non-autistic expressions of anger, happiness, and sadness (see Table 4).

Thus, while autistic posers' expressions were rated as more awkward/posed for some emotions, they were also rated as better/more intense for others. I next consider whether the awkwardness/posedness composite and/or the goodness/intensity composite could be used to predict how well expressions were identified, above and beyond poser neurotype.

Table 4.

Study 3 Pairwise Comparisons Between Autistic and Non-Autistic Posers, Broken Down by Each Rating Composite and Emotion.

Rating Dimension	Emotion	Autistic Poser Mean	Non-Autistic Poser Mean	*t* (26.6)	*p*	Effect Size
Awkward/ Posed						
	Anger	**3.24**	**2.61**	**4.20**	**< .001**	**0.60**
	Disgust	**3.12**	**2.77**	**2.30**	**.029**	**0.33**
	Fear	2.81	2.76	0.39	.702	0.06
	Happiness	2.50	2.59	-0.60	.552	-0.09
	Sadness	**2.86**	**2.49**	**2.48**	**.020**	**0.35**
	Surprise	2.94	2.86	0.51	.618	0.07
Good/Intense						
	Anger	3.00	2.84	1.06	.299	0.15
	Disgust	**3.78**	**3.19**	**3.95**	**< .001**	**0.56**
	Fear	**3.03**	**2.36**	**4.47**	**< .001**	**0.64**
	Happiness	3.33	3.21	0.80	.429	0.11
	Sadness	2.84	2.58	1.70	.102	0.24
	Surprise	**3.20**	**2.62**	**3.87**	**< .001**	**0.55**

Note. Reported effect size is from the “eff_size” function in the “emmeans” package (Lenth, 2022). It should be interpreted equivalently to Cohen’s D (Cohen, 1992).

Importance of Ratings for Recognition Accuracy

For each of the 144 expressions in the stimulus set, I first calculated the proportion of participants in Study 1 who correctly recognized that expression[8]. Then, I calculated from participants in Study 3 the average awkwardness/posedness and goodness/intensity scores for each of the 144 expressions. I fit a simple linear model[9] to predict recognition accuracy (from Study 1) with the expressions' awkwardness/posedness and goodness/intensity scores (from Study 3's data), neurotype of the poser, and the emotion being expressed. I conducted an "importance analysis" to determine each predictor's independent contribution to the variance in recognition accuracy explained by the model. I then conducted bootstrapped pairwise comparisons of these contributions to see whether any predictor contributed significantly more to the variance in recognition accuracy explained by the model than any other predictor. I used the "relaimpo" package in R to conduct these analyses (Grömping, 2007).

The omnibus test for the linear model was significant, $F(8, 135) = 45.89$, $p < .001$, $R^2_{adjusted} = .72$. However, only the goodness/intensity composite and emotion category were significant predictors (see Table 5 for full inferential statistics). For every one-unit increase in average goodness/intensity, recognition accuracy went up by 23%. Several of the emotion categories (fear, happiness, sadness, and surprise) differed from the reference level, expressions of anger. Neither poser neurotype nor awkwardness/posedness composite significantly predicted expression recognition accuracy.

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[8] Importance analyses with the recognition accuracy data from Study 2's untimed condition yielded the same pattern. See Appendix C for relevant statistics.

[9] I also fit this data to a linear mixed effects model with random intercepts for each poser. Both the simple linear regression and linear mixed effects models estimated the same coefficients. Given that the simple linear regression was more parsimonious and had better fit statistics (see Appendix C for relevant statistics), it is used here.

Table 5.

Study 3 Estimated Coefficients from Linear Model Predicting Recognition Accuracy with Two Composite Rating Variables.

	β	$t(135)$	p
Intercept	**-0.33**	**-3.08**	**.003**
Emotion- Disgust	0.00	0.08	.938
Emotion- Fear	**-0.20**	**-4.04**	**< .001**
Emotion-Happiness	**0.35**	**7.15**	**< .001**
Emotion-Sadness	**0.16**	**3.18**	**.002**
Emotion-Surprise	**0.11**	**2.33**	**.021**
Neurotype- Non-Autistic	0.02	0.70	.486
Goodness/Intensity Rating	**0.23**	**12.32**	**< .001**
Awkwardness/Posedness Rating	0.04	1.37	.173

Note. The intercept term in this model represents the estimate for autistic (the reference level for poser neurotype) expressions of anger (the reference level for emotion category) with a goodness/intensity and awkwardness/posedness score of 0. The coefficient for poser neurotype should be interpreted as the difference in recognition accuracy between autistic and non-autistic posers. Coefficients for the levels of emotion should be interpreted as the difference in recognition accuracy from that level of the variable to the reference level.

I next conducted an importance analysis to determine whether any predictor was more important than any other predictor for explaining the variance in emotion recognition accuracy. The results of this analysis revealed that the goodness/intensity dimension (38%; 95% CI [27%, 47%]) and the emotion depicted for an expression (34%; 95% CI [26%, 46%]) contributed the most to the variance explained by the model. The poser's neurotype (1%; 95% CI [0%, 3%]) and the awkwardness/posedness dimension (0%, 95% CI [0%, 2%]) each contributed very little. The results of the bootstrapped pairwise comparisons indicated that the goodness/intensity dimension and the emotion depicted did not significantly differ from one another, but both significantly differed from poser neurotype and the awkwardness/posedness dimension. Furthermore, poser neurotype and the awkwardness/posedness dimension did not significantly differ from one another.[10] Thus how good/intense a face appears to a non-autistic participant explains how well that expression is recognized above and beyond whether that expression comes from an autistic or non-autistic poser.

Discussion

Compared to expressions produced by non-autistic posers, expressions produced by autistic posers were rated as more awkward/posed (particularly for anger, disgust, and sadness) and better/more intense (particularly for disgust, fear, and surprise). Findings from the awkwardness/posedness composite are not surprising: Non-autistic people perceive autistic people's facial expressions as awkward (e.g., DeBrabander et al., 2019; Grossman et al., 2013; Grossman, 2015; Sasson et al., 2017). But the finding that autistic faces were rated as better/more intense is surprising. A good deal of prior literature has found that autistic people tend to exhibit "flat affect" (Bieberich & Morgan, 2004; Czapinksi & Bryson, 2003; Dawson et al., 1990; Kasari et al., 1990; Stagg et al., 2014). Thus, one might have expected autistic expressions to be rated as less intense than the non-autistic expressions, which would have

[10] I do not report exact *p*-values for these analyses because the "relaimpo" package generates 95% confidence intervals for these estimates. Statistical significance for pairwise comparisons is determined based on whether these confidence intervals overlap. The exact confidence intervals can be seen in Appendix C.

resulted in lower goodness/intensity ratings. In fact, I found the opposite: Expressions produced by autistic posers received higher goodness/intensity ratings.

There are at least two possibilities for why expressions from autistic posers were rated as better and more intense examples of the intended emotions than those from non-autistic posers. First, while flat affect is a common aspect in autism, it is not universal (e.g., Konstantareas & Hewitt, 2001). Perhaps the 12 autistic posers represented in Brewer et al.'s (2016) stimuli happen to be autistic people who are particularly expressive. Second, some autism interventions focus on training autistic people how to produce intense facial emotional expressions (e.g., Grossard et al., 2017, 2018; Hassan et al., 2021). For example, Gordon et al. (2014) attempted to train autistic children to make "better" emotional expressions by playing a game that only progressed when they made a "good" example of an expression. Quality of the expression was determined by measuring the extent to which children activated facial muscles relevant to the target emotion. The higher the activation (i.e., the more intense), the "better" the expression was deemed, and thus the game would progress. It is not possible to know whether any of the autistic posers in the stimulus set received similar kinds of feedback about producing "good" examples of emotional expressions. But it is possible that one way autistic people might adapt to the lived experience of having their emotions misunderstood is by exhibiting emotional expressions of a high intensity.

The results of Studies 1 through 3 could be interpreted to mean that there is more overlap in the internal representations of non-autistic participants and the autistic posers than the non-autistic participants and non-autistic posers. Indeed, based on the logic I provided in the Introduction, non-autistic participants' higher emotion recognition accuracy for autistic expressions (and their rating autistic expressions as better/more intense) would suggest this. However, I think this is unlikely. Other research has shown that members of the same cultural group tend to have representations that are shared with ingroup members, but not necessarily with outgroup members (Jack et al., 2009; Jack, Caldara, et al., 2012; Jack, Garrod, et al., 2012). Admittedly, the posers and observers in my study do come from different countries: the posers from the UK, the observers from the US. One might argue that there are cultural differences in how emotions are expressed in these countries (e.g., the UK's "stiff upper lip" vs. the US's tendency to be "overly emotional"). Perhaps the non-autistic participants do not share as much cultural ground with the non-autistic posers as one might expect (though, the same would be true of the non-autistic participants and the autistic posers). However, I do not believe this is the case.

Both the US and the UK constitute WEIRD cultures: Western, educated, industrialized, rich, and democratic (Henrich et al., 2010). Therefore, despite slight nationality-based cultural differences in when emotion tends to be expressed, the largest cultural difference that presumably exists amongst these three groups of people is that of neurotype. In fact, autistic people are sometimes described as comprising a unique cultural group relative to non-autistic people (e.g., Botha & Frost, 2020; Leadbitter et al., 2021), just as disabled people form a distinct cultural group from non-disabled people (e.g., Kaplan & Liu, 2000; Nario-Redmond & Oleson, 2016; Nario-Redmond et al., 2012). Therefore, it seems unlikely that the non-autistic participants in this sample have more shared cultural ground (and thus shared internal representations for emotional expressions) with the autistic posers than the non-autistic posers.

Instead, I argue that the autistic and non-autistic posers represented in the stimulus set used in Studies 1-3 have similar internal representations for emotional expressions. However, they expressed them differently because of differences in the way they interpreted the instructions that were used to invite them to pose in each expression. I investigate this possibility in Study 4.

Study 4- Did the Instructions Given to Posers Influence How Posers Produced Their Expressions, Leading Them to be Perceived Differently?

It is possible that the autistic and non-autistic posers represented in Brewer et al.'s (2016) stimulus set (and used in Studies 1-3) held *similar* internal representations for emotional expressions but drew on those representations differently when producing the expressions. Recall that the expressions used in Studies 1-3 came from Brewer et al.'s (2016) standard condition, where posers were instructed to "pose each emotion to the best of [your] ability using facial expressions" (p. 264). In those instructions, posers were not provided any information about why they were being asked to produce these expressions, or who the expressions were intended for.

The lack of context in those instructions is important, since prior work has found that when asked to draw on emotion information to complete a task, people will draw on the emotion information most salient to them—typically either their recent emotional experiences or their internal representations for emotions, depending on the context (Robinson & Clore, 2002). When participants are asked to report on recent events, they tend to draw on their memories of the emotions they actually experienced because those memories are readily available. However, when participants are asked to report on events from the past, they tend to report on their *expectations* for how they would have felt in that context, rather than their actual memories of their emotional experiences.

This is relevant to explaining why autistic and non-autistic posers may have had similar internal representations for emotional expressions but manifested them differently when posing for the stimuli used in Studies 1-3. For the non-autistic posers, the most salient information may have been their most recent emotional experiences, and so they may have drawn on that information more than their internal representations when posing. For the autistic posers, the most salient information may have been their internal representations. This is because, as noted in the Introduction, autistic people experience higher levels of alexithymia than non-autistic people (Berthoz & Hill, 2005; Hill et al., 2004; Lombardo et al., 2007; Milosavljevic et al., 2016). Given that alexithymia entails difficulty identifying or describing one's own emotions (Bagby et al., 1994; Nemiah & Sifneos, 1970), it is likely that the autistic posers in Brewer et al. (2016)[11] would have been less likely than the non-autistic posers to draw on their recent emotional experiences when posing for the photos. In other words, autistic posers may have been more likely to draw on their internal representations when posing than non-autistic posers, who drew on their recent emotional experiences.

Fortunately, Brewer et al. (2016) also had the same posers create facial expressions in a "communicate" condition. Here, posers were explicitly instructed to produce emotional expressions "in a way that would allow the experimenter to guess which emotion was being expressed" (Brewer et al., 2016, p. 265). I hypothesized that by making explicit that the purpose of the task was to communicate an emotion to someone else, both groups of posers would be likely to draw on their internal representations and so the stimuli from this communicate condition may more accurately reflect the internal representations of both the autistic and non-autistic posers.

Before testing whether autistic and non-autistic expressions produced in the communicate condition of Brewer et al. (2016) would be equally well recognized by non-autistic participants, I first conducted a study analogous to Study 3: I asked whether expressions produced by the two neurotypes would be rated by non-autistic participants as equally good and intense examples of

[11] Brewer et al. (2015) do not state the level of alexithymia for either the autistic or non-autistic posers. However, they do explain that alexithymia score was correlated strongly with a measure of autism symptomatology in their sample, $r = .67$. Presuming that the autistic posers had higher scores on the measure of autism symptomatology than the non-autistic posers, one can also infer that they likely had higher levels of alexithymia.

the intended emotion. (Note that I did not ask participants to rate the "awkwardness" or "posedness" of the expressions, as Study 3 found these ratings contributed very little variance to recognition accuracy.) If there was no difference between the autistic and non-autistic faces in perceived goodness/intensity for stimuli from the communicate condition, that would suggest the two groups were drawing on similar internal representations, and the communicate condition accurately captured those representations. I would then conduct Study 5 to confirm this hypothesis using an emotion recognition paradigm with the expressions from the standard and communicate conditions.

Method

Participants

Participants were 148 non-autistic undergraduates at the University of Virginia, who participated for course credit. Data from 14 additional participants were collected, but their data are not reported here because they self-identified as autistic (2); because they failed to pass all attention checks described below (9); or because they completed the study in less than 10 minutes (3). I did not conduct an a priori power analysis, and sample size was determined based on the number of participants available to the researcher via the undergraduate participant pool. Data were collected over three weeks from February to March 2022.

Participant demographics are reported in Table 6, but the sample resembled that of the previous studies. Participants were, on average, 19 years old (M_{age} = 19.26, SD_{age} = 1.16, *Range* = 18-22 years old), mostly identified as female (76%), and were mostly White (62%).

Table 6.

Study 4 Participant Demographics

	Female	Male	Non-Binary	Decline to Identify
N (%, N)	76% (113)	22% (33)	1% (1)	1% (1)
Age (M, SD)	19.05 (0.96)	19.81 (1.40)	22.00 (NA)	22.00 (NA)
Race (%, N)				
African American	8% (9)	9% (3)	-	-
Asian American	19% (22)	24% (8)	-	-
White	64% (72)	61% (20)	-	-
Multiple Races	6% (7)	6% (2)	100% (1)	-
Decline to Answer	3% (3)	-	-	100% (1)
Ethnicity				
Hispanic/Latinx	4% (4)	3% (1)	100% (1)	-
Non-Hispanic/Latinx	95% (107)	94% (31)	-	-
Decline to Answer	2% (2)	3% (1)	-	100% (1)

Stimuli

Stimuli included images of the same 12 autistic and 12 non-autistic posers included in Studies 1, 2, and 3. However, the previous studies involved stimuli from Brewer et al.'s (2016) standard condition only. In Study 4, I used stimuli created for both the standard condition and the communication condition. In the standard condition, posers were told to "pose each emotion to the best of [your] ability using facial expressions" (Brewer et al., 2016, p. 264). There was no explicit communicative purpose of the expression. In the communicate condition, posers were told to pose each expression "in a way that would allow the experimenter to guess which emotion was being expressed" (Brewer et al., 2016, p. 265). I used 144 images from the standard condition of Brewer et al., but I used only 137 images from the communicate condition because images in this condition were missing from one autistic poser, and the anger image from one autistic poser was not available.

Procedure

Participants completed the study on Qualtrics. Participants were randomly assigned to view the stimuli from either the standard ($N = 74$) or communicate ($N = 74$) conditions. Within each condition, faces were presented to participants in a randomized order. Faces were shown one at a time, in a random order.

As in Study 3, for each face, participants were told what emotion the expression was intended to convey (e.g., "This face is an expression of: Surprise"). They then responded to the two questions "How intense is this expression of [surprise]?", "How good is this expression of [surprise]?" Questions were presented in that order for every trial, for every participant. Participants made their ratings on a 5-point Likert scale (*Not at all*, *Slightly*, *Mildly*, *Moderately*, and *Very*) by clicking a radio button. Participants could take as much time as they needed to make their ratings, and they could change any rating until they clicked a button to advance to the next trial. The face remained visible until they did so.

As an attention check, six of the trials included an additional prompt asking participants to select a specific response option (e.g., "Click on 'Not at all'"). Whether a prompt appeared before, in the middle, or after the other two ratings varied over the attention checks, as did which response option was prompted. As noted above, data from nine participants were excluded because they failed one or more of the six attention checks they encountered. Finally, data and code for this study can be found at https://osf.io/jwt8a.

Results

As in Study 3, I averaged "intensity" and "goodness" scores to create a composite goodness/intensity score. As Figure 10 shows, and replicating the results of Study 3, for faces in the standard condition, autistic posers were rated as producing better/more intense expressions, particularly for expressions of disgust, fear, and surprise. However, in the communicate condition, where posers were told to produce a face that could be guessed by the experimenter, there was no difference in how good/intense the autistic and non-autistic faces were judged to be.

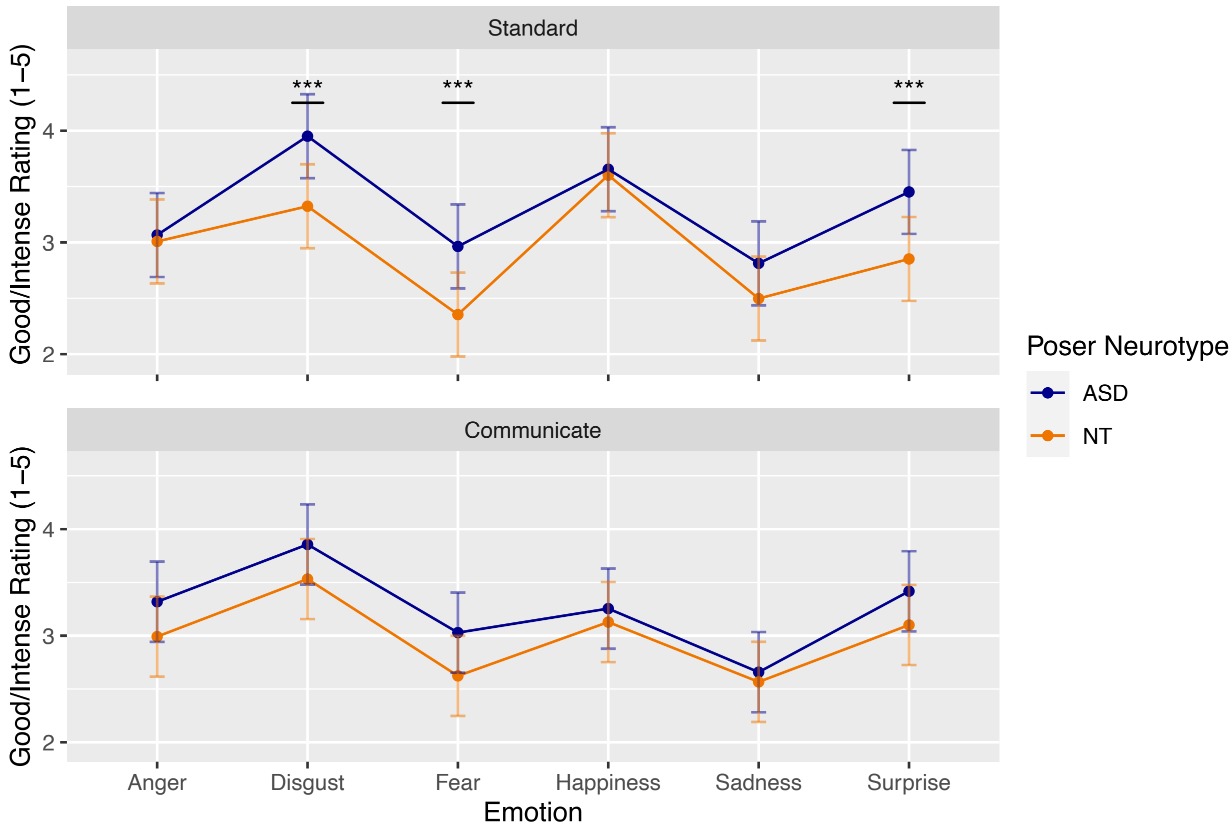

Figure 10. Study 4 goodness/intensity composite ratings as a function of poser neurotype and emotion in the standard (top panel) and communicate (bottom panel) conditions. Error bars represent the 95% confidence interval. Asterisks indicate whether goodness/intensity ratings for autistic and non-autistic expressions differed. *** $p < .001$.

A 2 (poser group: autistic vs. non-autistic) x 2 (stimulus condition: standard vs. communicate) x 6 (emotion category: anger, fear, disgust, happiness, sadness, and surprise) ANOVA on the data in Figure 10 revealed a significant three-way interaction between poser neurotype, stimulus condition, and emotion, $F(5, 20601.9) = 10.51$, $p < .001$.

To follow up on this three-way interaction, I conducted separate analyses on poser neurotype and emotion separately for the standard and communicate conditions. For the standard condition, there was a two-way interaction between poser neurotype and emotion, $F(5, 20601.87) = 30.94$, $p < .001$: Expressions produced by autistic posers received higher goodness/intensity ratings than those produced by non-autistic posers when expressing disgust, fear, and surprise. Pairwise comparisons between autistic and non-autistic posers for anger, happiness, and sadness did not show differences between the two neurotypes in how good/intense they were (see Table 7).

For the stimuli from the communicate condition, there was also a two-way interaction between poser neurotype and emotion, $F(5, 20602.21) = 6.209$, $p < .001$. However, in this case none of the pairwise comparisons between autistic and non-autistic posers for any of the emotions showed differences between the two neurotypes in how good/intense their expressions were (see Table 7).

Table 7.

Study 4 Pairwise Comparisons Between Autistic and Non-Autistic Posers, Broken Down by Each Stimuli Condition and Emotion

Stimuli Condition	Emotion	Autistic Poser Mean	Non-Autistic Poser Mean	df	*t*-statistic	*p*	Effect Size
Standard							
	Anger	3.07	3.01	23.6	0.23	.820	0.06
	Disgust	**3.95**	**3.32**	**23.6**	**2.49**	**.021**	**0.60**
	Fear	**2.96**	**2.35**	**23.6**	**2.42**	**.024**	**0.59**
	Happiness	3.66	3.60	23.6	0.21	.834	0.05
	Sadness	2.81	2.50	23.6	1.25	.224	0.30
	Surprise	**3.45**	**2.85**	**23.6**	**2.38**	**.026**	**0.58**
Communicate							
	Anger	3.32	2.99	23.8	1.29	.209	0.31
	Disgust	3.86	3.53	23.7	1.29	.211	0.31
	Fear	3.03	2.62	23.7	1.61	.121	0.39
	Happiness	3.25	3.13	23.7	0.50	.621	0.12
	Sadness	2.66	2.57	23.7	0.36	.721	0.09
	Surprise	3.42	3.10	23.7	1.25	.222	0.30

Note. Effect size reported is from the “eff_size” function in the “emmeans” package (Lenth, 2022). It should be interpreted equivalently to Cohen’s D.

Discussion

In the standard condition, autistic posers’ expressions were rated as better/more intense than non-autistic posers’ expressions, replicating the findings of Study 3. But in the newly added communicate condition—where posers had been instructed to make expressions that would allow the experimenter to guess the emotion—autistic and non-autistic posers’ expressions were rated similarly.

It is not possible to know for certain why the non-autistic posers created better and more intense expressions in the communicate than standard condition. However, these results are consistent with my prediction that instructions emphasizing the communicative purpose of these expressions would lead both the autistic and non-autistic posers to produce expressions that were more accurate reflections of their internal representations for emotional expressions. Furthermore, these results suggest that the two groups have similar internal representations for emotional expressions. Given that there was no difference between the two neurotypes in goodness/intensity ratings in the communicate condition and given that goodness/intensity ratings contributed the most variance to recognition accuracy in Study 3, I predicted that there would be no difference in recognition accuracy between autistic and non-autistic faces produced in the communicate condition. Testing this hypothesis was the focus of Study 5.

Study 5- Are Expressions Produced by Autistic and Non-Autistic Posers Recognized Differently in the Standard versus Communicate Conditions?

Study 5 had two goals. The first goal was to compare recognition accuracy for autistic and non-autistic expressions produced in the standard and communicate conditions of Brewer et al. (2016). I hypothesized that autistic expressions from the standard condition would be recognized more accurately than the non-autistic expressions, replicating the findings of Studies 1 and 2. But I expected that there would be no difference in recognition accuracy between autistic and non-autistic expressions from the communicate condition because Study 4 showed that the non-autistic expressions were considered as good/intense as the autistic expressions. The second goal of Study 5 was to investigate how well the goodness and intensity ratings could predict recognition accuracy in the standard and communicate conditions.

Method

Participants

Prior to data collection, I conducted an a-priori power analysis using the "simr" package in R (Green & MacLeod, 2016). This power analysis indicated that to be sufficiently powered (i.e., 80% power with an alpha level of .05) to detect a significant three-way interaction between poser neurotype, emotion, and stimulus condition would require 320 participants (160 per group).

Participants were 344 non-autistic undergraduates at the University of Virginia, who participated for course credit. Data from 42 additional participants were collected, but their data are not reported here because they did not complete the study (18); because they self-identified as autistic (23); or because their overall emotion recognition accuracy score was exactly 0.167 (one sixth), suggesting they selected only one response option for every trial (1). Data were collected over two weeks in September 2022. Of the 344 participants in the final sample, 168 were randomly assigned to see stimuli from the communicate condition, and 176 to see stimuli from the standard condition.

Participant demographics are reported in Table 8, but the sample resembled those of the previous studies. Participants were, on average, 18 years old (M_{age} = 18.82, SD_{age} = 1.25, *Range* = 18-29 years old), mostly identified as female (79%), and were mostly White (62%).

Table 8.

Study 5 Participant Demographics

	Female	Male	Non-Binary	Decline to Identify
N (%, N)	79% (270)	20% (69)	1% (3)	1% (2)
Age (M, SD)	18.70 (1.11)	19.28 (1.63)	18.67 (1.53)	20.00 (1.41)
Race (%, N)				
African American	7% (18)	4% (3)	-	-
Asian American	21% (57)	26% (18)	-	-
Native American/ Alaskan Native	0.4% (1)	-	-	-
White	62% (168)	61% (42)	33% (1)	100% (2)
Other	2% (5)	1% (1)	33% (1)	-
Multiple Races	7% (19)	6% (4)	33% (1)	-
Decline to Answer	1% (2)	1% (1)	-	-
Ethnicity				
Hispanic/Latinx	8% (22)	4% (3)	33% (1)	-
Non-Hispanic/Latinx	85% (229)	88% (61)	67% (2)	100% (2)
Unknown	3% (8)	4% (3)	-	-
Decline to Answer	4% (11)	3% (2)	-	-

Stimuli

Stimuli were the same as those used in Study 4.

Procedure

The procedure was generally the same as that used in Studies 1 and 2. Participants completed the study online via Qualtrics. For each expression they saw, they indicated which of the six emotions it showed; the face remained visible until they made a selection.[12] Participants were randomly assigned to see the expressions created in the standard or communicate conditions of Brewer et al. (2016).

Broad Autism Phenotype Questionnaire (BAP-Q; Hurley et al., 2007)

After completing the emotion recognition paradigm, participants completed the BAP-Q. Recall that the BAP-Q is a 36-item questionnaire that assesses participants' self-reported level of autistic traits. Internal consistency for the BAP-Q in Study 5 was high (*Cronbach's* $\alpha = 0.89$, 95% CI [0.87, 0.90]).

Data Availability

This study was pre-registered at https://osf.io/4298u. Data and code for this study can be found at https://osf.io/jwt8a.

Results

Emotion Recognition

Emotion Recognition Accuracy

As expected and as Figure 11 shows, autistic expressions in the standard condition were recognized more accurately than non-autistic expressions, replicating Studies 1 and 2. However,

[12] I did not limit participants' exposure to the stimuli as I wished to replicate the methodology used in Study 1, and because Study 2 found that the patterns in recognition accuracy for autistic and non-autistic posers in the different emotions was not affected by stimulus duration.

contrary to expectations, autistic expressions in the communicate condition were recognized more accurately than non-autistic expressions.

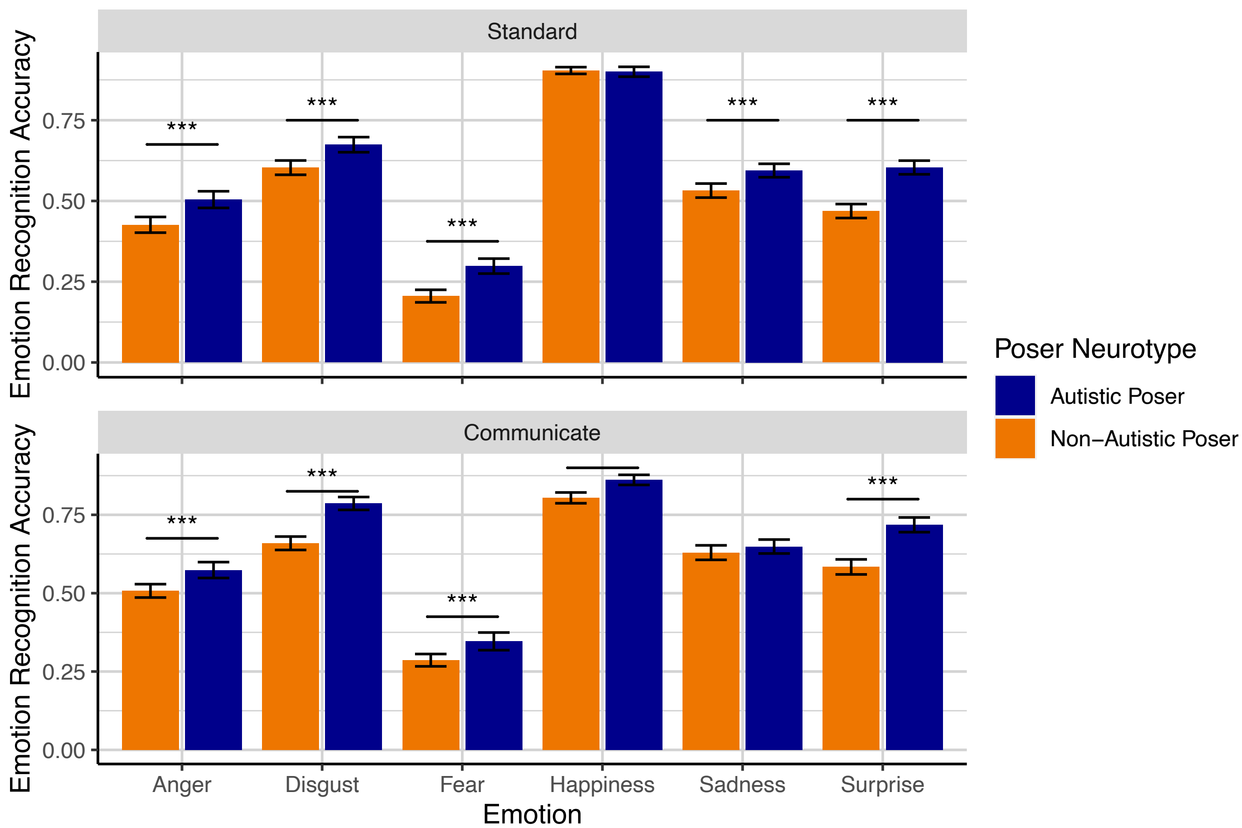

Figure 11. Study 5 average recognition accuracy as a function of poser neurotype and emotion in the standard (top panel) and communicate (bottom panel) conditions. In both panels, error bars represent the 95% confidence interval. Asterisks indicate whether recognition accuracy for autistic and non-autistic posers differed from each other. *$p < .05$, *** $p < .001$.

A 2 (poser neurotype) x 6 (emotion) x 2 (stimulus condition) ANCOVA—with BAP-Q as a covariate—on the data shown in Figure 11 revealed significant main effects of poser neurotype, $F(5, 3762) = 295.84$, $p < .001$, emotion, $F(5, 3762) = 1308.62$, $p < .001$, and condition, $F(1, 341) = 104.71$, $p < .001$. The two-way interactions between poser neurotype and emotion, $F(5, 3762) = 13.40$, $p < .001$, and emotion and condition, $F(5, 3762) = 36.40$, $p < .001$, were significant, but the two-way interaction between poser neurotype and condition, $F(1, 3762) = 0.32$, $p = .574$, was not. However, there was also a significant three-way interaction between poser neurotype, emotion, and condition, $F(5, 3762) = 4.28$, $p < .001$. Finally, the effect of the covariate (BAP-Q) in this analysis was not statistically significant, $F(1, 341) = 1.41$, $p = .237$, suggesting the patterns of emotion recognition accuracy were not affected by participants' self-identified level of autistic traits.

I had expected a significant three-way interaction between poser neurotype, emotion, and condition, but that the underlying two-way interaction between poser neurotype and emotion would be significant only in the standard condition. As expected, the two-way interaction between poser neurotype and emotion was significant in the standard condition, $F(5, 3762) = 9.23$, $p < .001$. Further analyses on this interaction revealed that the autistic expressions were recognized more accurately than the non-autistic expressions in all emotions except for happiness (see Table 9 for full inferential statistics).

Contrary to my expectations, the two-way interaction between poser neurotype and emotion was also significant in the communicate condition, $F(5, 3762) = 8.48$, $p < .001$. Here, autistic expressions were recognized more accurately than the non-autistic expressions for all emotions except for sadness (see Table 9 for full inferential statistics). Together, these results suggest that emotional expressions produced by the autistic posers were recognized more accurately than emotional expressions produced by the non-autistic posers, and this was true regardless of whether posers were instructed to make expressions that would be recognizable to someone else (the communicate condition) or not (the standard condition).

Table 9.

Study 5 Pairwise Comparisons for Emotion Recognition Accuracy Scores Between Autistic and Non-Autistic Posers, Broken Down by Each Stimulus Condition and Emotion

Stimuli Condition	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	*t*(3762)	*p*	Effect Size
Standard						
	Anger	**.50 (.17)**	**.43 (.16)**	**5.24**	**< .001**	**0.56**
	Disgust	**.67 (.16)**	**.60 (.15)**	**4.76**	**< .001**	**0.51**
	Fear	**.30 (.16)**	**.21 (.13)**	**6.22**	**< .001**	**0.66**
	Happiness	.90 (.10)	.90 (.07)	-0.25	.800	-0.03
	Sadness	**.59 (.14)**	**.53 (.15)**	**4.16**	**< .001**	**0.44**
	Surprise	**.60 (.14)**	**.47 (.15)**	**9.04**	**< .001**	**0.96**
Communicate						
	Anger	**.57 (.17)**	**.51 (.14)**	**4.35**	**< .001**	**0.47**
	Disgust	**.79 (.14)**	**.66 (.14)**	**8.32**	**< .001**	**0.91**
	Fear	**.35 (.18)**	**.29 (.13)**	**3.94**	**< .001**	**0.43**
	Happiness	**.86 (.11)**	**.80 (.11)**	**3.76**	**< .001**	**0.41**
	Sadness	.65 (.15)	.63 (.15)	1.27	.205	0.14
	Surprise	**.72 (.15)**	**.58 (.16)**	**8.79**	**< .001**	**0.96**

Note. Effect size reported is from the "eff_size" function in the "emmeans" package (Lenth, 2022). It should be interpreted equivalently to Cohen's D.

Wagner's UHR

For Wagner's UHR I also conducted a 2 x 6 x 2 ANCOVA with level of autistic traits as a covariate, and poser neurotype, emotion, and condition as independent variables. These analyses revealed a similar pattern to the emotion recognition accuracy analyses. The effect of the covariate (BAP-Q) was not significant, $F(1, 340.6) = 1.25$, $p = .265$. The three main effects were all significant: poser neurotype, $F(1, 3751.7) = 812.12$, $p < .001$; emotion, $F(5, 3751.7) = 2526.92$, $p < .001$; condition, $F(1, 340.9) = 99.28$, $p < .001$. All three of the two-way interactions were also significant: poser neurotype by emotion, $F(5, 3751.3) = 26.86$, $p < .001$; poser neurotype by condition, $F(1, 3751.3) = 4.70$, $p = .030$; emotion by condition, $F(5, 3751.7) = 96.02$, $p < .001$. Finally, the three-way interaction between poser neurotype, emotion, and condition was also significant, $F(5, 3751.3) = 4.59$, $p < .001$. In following up on the three-way interaction, I investigated the effects of poser neurotype and emotion at each level of posing condition. The full inferential statistics for these analyses can be found in Appendix D, but to summarize: the pattern of results was very similar to that reported for emotion recognition accuracy. Expressions produced by autistic posers were recognized significantly more accurately for all emotions in both conditions.

Importance Analyses

Next, to investigate which variables are most important for recognition accuracy, I fit a linear model with the proportion of times each expression (from both the standard and communicate conditions) was correctly identified, predicted by poser neurotype, emotion, condition, and goodness/intensity score (from Study 4). The omnibus test for this model was significant $F(8, 272) = 103.60$, $p < .001$, $R^2_{adjusted} = .75$. In this model, there were several significant predictors, including average goodness/intensity rating, stimulus condition, and several of the emotion categories (as in Study 3, a separate estimate was calculated for each emotion category). Importantly, however, once these other factors were accounted for, the effect of poser neurotype was no longer significant (see Table 10 for full inferential statistics). This suggests that the effect of poser neurotype on recognition accuracy was driven by one or more of these factors.

Table 10.

Study 5 Estimated Coefficients from Linear Model Predicting Recognition Accuracy with One Composite Rating Variable.

	β	$t(272)$	p
Intercept	-0.24	-5.18	< .001
Emotion- Disgust	0.04	1.10	.271
Emotion- Fear	-0.13	-4.06	< .001
Emotion-Happiness	0.28	8.67	< .001
Emotion-Sadness	0.21	6.31	< .001
Emotion-Surprise	0.06	1.88	.061
Neurotype- Non-Autistic	0.02	0.97	.331
Goodness/Intensity Rating	0.24	21.22	< .001
Condition	-0.05	-2.41	.017

Note. The intercept term in this model represents the estimate for autistic expressions of anger in the standard condition (the reference levels for each of the categorical variables) with a goodness/intensity score of 0. Coefficients for the levels of the categorical variables should be interpreted as the difference in recognition accuracy from that level of the variable to the reference level.

Next, as in Study 3, to investigate how much each factor contributed to recognition accuracy, and whether any effect superseded the effect of poser neurotype, I conducted an importance analysis. The results of this analysis revealed that goodness/intensity rating contributed the most to recognition accuracy (48%; 95% CI [41%, 55%]), followed by emotion depicted (26%; 95% CI [21%, 33%]). The amount of variance in recognition accuracy explained by both goodness/intensity and emotion depicted were significantly greater than the amount explained by poser neurotype (1%; 95% CI [0%, 3%]) and the stimulus condition (1%; 95% CI [0%, 3%]), which did not differ from each other[13]. Thus, after accounting for the goodness/intensity of a given expression, poser neurotype was not a significant predictor of recognition accuracy in the linear model reported above, and it contributes much less variance in recognition accuracy than goodness/intensity rating. Together, these findings are similar to those of Study 3 in that perceived goodness/intensity of an expression seems to contribute more variance to emotion recognition accuracy than a poser's being autistic or not.

Discussion

Contrary to my expectations, autistic expressions were recognized more accurately than non-autistic expressions in both the standard and communicate conditions of Study 5. Further, the perceived goodness/intensity of an expression (obtained in Study 4) explained the most variance in recognition accuracy in the standard *as well as the communicate* conditions even though I found in Study 4 that there was no difference in perceived goodness/intensity between the autistic and non-autistic expressions in the communicate condition. This pattern of findings is perplexing.

[13] See Table D4 in Appendix D for full bootstrapped confidence intervals and comparisons.

Recall that I earlier suggested that because of the ambiguous nature of the instructions in the "standard condition" of Brewer et al. (2016), the autistic and non-autistic posers may have drawn on different types of information when creating the expressions used in Studies 1-3. When told to "pose each emotion to the best of [your] ability using facial expressions" (Brewer et al., 2016, p. 264), I suggested that non-autistic posers may have relied more on their memories of those emotions than autistic posers, whereas autistic posers (who have higher levels of alexithymia) may have relied more on their internal representations of those emotions. I had proposed that if the instructions given to the posers were more explicitly about communicating the emotion to another person (posers were told to make each expression "in a way that would allow the experimenter to guess which emotion was being expressed"; Brewer et al., 2016, p. 265), then both the non-autistic and autistic posers would draw on their internal representations, and expressions from the two neurotypes would be equally good/intense (as Study 4 found) and equally well recognized (which Study 5 failed to find).

Perhaps I was incorrect to assume that the non-autistic posers would draw on their internal representations more heavily in the communicate condition. Or, perhaps the emphasized communicative context in the instructions for the communicate condition were not a strong enough manipulation to elicit such an effect. With the present data it is not possible to determine which of these possibilities is true. Future research could investigate whether task demands make it more likely for autistic and non-autistic people to rely solely on their internal representations when making an expression in ways similar to those reported in Robinson and Clore (2002) and described in the introduction to Study 4.

Still, the results from Study 5 are useful for answering my primary question—that is, whether differences in internal representations contribute to why non-autistic people sometimes have difficulty understanding the emotions experienced by autistic people. Given that non-autistic participants have consistently recognized autistic expressions better than non-autistic expressions, differences in internal representations seem unlikely to play a role in these misunderstandings.

General Discussion

Motivation, Methods, and Findings

These studies were motivated by a common, troubling experience many autistic people have described—namely, having their emotions misunderstood by non-autistic people in everyday interactions (e.g., @Autisong, 2021; Camm- Crosbie et al., 2019; Crompton, Hallett, et al., 2020; Robison, 2011; Robledo et al. 2012). Autistic people report that these misunderstandings about emotion have significant negative impacts on their well-being (e.g., Camm-Crosbie et al., 2019).

One reason non-autistic people might misunderstand autistic people's emotions could be because the two groups have different internal representations of emotion, particularly for the facial expression of emotion. Internal representations for the facial expression of emotion guide the production of emotional expressions (e.g., Clore & Ortony, 1991; Jack & Schyns, 2015; Ortony et al., 1988), as well as the interpretation of them (e.g., Binetti et al., 2022; Bird & Viding, 2014; Goldman & Sripada, 2005; Jack & Schyns, 2015). Cross-cultural misunderstandings about emotion have been traced, in part, to differences in internal representations for emotional expressions (e.g., Jack, Caldara et al., 2012; Jack, Garrod, et al., 2012). Thus, there was reason to believe that autistic and non-autistic people, who make up distinct cultural groups of their own (e.g., Botha & Frost, 2020; Leadbitter et al., 2021), might also have different internal representations for emotional expressions.

I showed non-autistic participants photos of autistic and non-autistic adults posing in six different emotional expressions and asked participants to identify the depicted emotion. My logic was that non-autistic participants' recognition accuracy would be highest for faces that most closely matched their internal representations for emotional expressions. I was motivated by the work of both Brewer et al. (2016), whose stimuli are used in this dissertation, and Faso et al. (2015), who used a similar approach. Brewer et al. (2016) reported that autistic people's posed expressions were recognized less accurately than non-autistic people's, but their findings were based on a very small sample size and seemed to be driven by the better recognition of happiness on non-autistic compared to autistic faces. Faso et al. (2015) reported the opposite pattern: autistic expressions were recognized more accurately than non-autistic expressions, but their findings were also based on a small sample size and seemed to be driven by the better recognition of anger on autistic compared to non-autistic faces.

The studies reported here used much larger, well-powered samples to address how well non-autistic participants could recognize autistic vs. non-autistic facial emotional expressions. Study 1 showed, unexpectedly, that autistic expressions of anger, disgust, fear, sadness, and surprise were recognized more accurately than the non-autistic expressions (happiness was the only emotion recognized equally well). I replicated this general pattern of results in Study 2. In Study 3, I tried to identify what attributes of autistic expressions led to their being recognized more accurately than non-autistic expressions. I found that non-autistic participants perceived the autistic faces to generally be better and more intense examples of the emotions they were intended to convey (especially for disgust, fear, and surprise), compared to the non-autistic expressions. Furthermore, it was these attributes in particular that explained the most variance (of the measured factors) in how well an expression was recognized.

In Studies 4 and 5, I considered the possibility that the instructions given to the posers influenced the expressions they made. Brewer et al. (2016) created stimuli of the autistic and non-autistic posers both when they were told nothing about who the expressions were intended for (the standard condition) and when they were told that others would guess what emotion they were feeling from their expressions (the communicate condition). I hypothesized that the instructions in the communicate condition might lead the non-autistic posers to rely more on their internal representations than in the standard condition, where memories of past emotional experiences may have been more salient to them. In Study 4, autistic and non-autistic posers' expressions were rated as similar in goodness/intensity in the communicate condition (and I replicated the differences in goodness/intensity from the standard condition found in Study 3). But in Study 5, autistic expressions were still more accurately recognized than non-autistic expressions in both the standard and communicate conditions.

Although findings from Study 5 are puzzling, as a group, the five studies reported here provide an answer to the question I set out to address—namely, whether differences in internal representations of facial emotional expressions contribute to why non-autistic people sometimes have difficulty understanding what autistic people are feeling. The answer is no. Over five studies with over 1,100 non-autistic participants, I consistently found that autistic facial emotional expressions were recognized more accurately than non-autistic facial emotional expressions. The opposite pattern of results might have been consistent with the hypothesis that non-autistic and autistic people have different internal representations of emotional expressions that lead to cross-neurotype misunderstandings. But given that I consistently found an advantage in recognition accuracy for autistic over non-autistic expressions, it seems unlikely that differences in internal representations for emotional expressions contribute to non-autistic people misunderstanding autistic people's emotions.

In the sections that follow, I consider why the autistic posers' expressions were repeatedly recognized more accurately than the non-autistic posers' expressions. Next, I consider factors other than differences in internal representations that may contribute to why non-autistic people sometimes misunderstand the emotions autistic people experience. Finally, I close by discussing the limitations of this work.

Why Were Autistic Expressions Recognized More Accurately?

One reason why non-autistic participants recognized autistic posers' expressions better than non-autistic posers' expressions could be because the non-autistic participants' internal representations aligned more with the autistic posers' than the non-autistic posers'. In the Introduction, I raised the possibility that non-autistic participants could recognize autistic expressions more accurately, but noted that when I began this work, I did not consider it likely. In Study 3, after repeatedly finding that autistic expressions were better recognized than non-autistic expressions, I considered this possibility again, but argued that it still seemed unlikely that non-autistic participants' internal representations would overlap more with the internal representations of autistic compared to non-autistic posers. After all, the two neurotypes could be considered different cultural groups (e.g., Botha & Frost, 2020; Leadbitter et al., 2021), and it seems unlikely that non-autistic participants' internal representations would be more similar to those of autistic compared to non-autistic posers. In what follows, I offer two alternative possibilities: display rules and adaptation.

Part of emotion socialization includes learning "display rules:" norms about when it is and is not appropriate to demonstrate different emotions (Gnepp & Hess, 1986; Malatesta & Haviland, 1982; Saarni, 1979). Different cultures often have different display rules (e.g., Matsumoto, 1990; Matsumoto, 1993; Matsumoto et al., 2008; Safdar et al., 2009). For example, Japanese people show anger and fear to outgroup members more than Americans, while Americans show disgust and sadness to ingroup members more than Japanese people (Matsumoto, 1990). Despite these differences, however, there are also some cultural constants in display rules, the most notable of which may be that people are sensitive to how close of a relationship they have with the person they are expressing emotion to. Across the globe, people tend to show more emotion to family and friends than to strangers (Matsumoto et al., 2008; Zeman & Garber, 1996).

There is good reason to think that the autistic and non-autistic posers photographed by Brewer et al. (2016) may have been differently affected by the presence of the experimenters when posing their emotional expressions. There is some reason to believe that both groups of posers may have understood the display rule that one typically shows less emotion in front of strangers, but the autistic posers may not have been as likely to use that rule. For example, in one study (Begeer et al., 2011), when asked what look they would have on their face in a situation where a classmate accidentally ruined a drawing, both autistic and non-autistic children indicated that they would be expected to hide their displeasure about the ruined picture. However, when asked whether they would hide their displeasure, the autistic children reported that they would be less likely to do so than the non-autistic children.

We cannot know whether differential implementation of display rules may have affected the expressions autistic and non-autistic posers in Brewer et al. (2016) made. Indeed, one might expect that if the non-autistic posers were inhibited by the presence of the experimenter, they might make lower quality or less intense emotional expressions than the autistic posers. This was true of the non-autistic expressions in the standard condition of Study 3 and Study 4, but autistic and non-autistic expressions did not differ in goodness/intensity in the communicate condition of Study 4. Furthermore, the results of Study 5 suggest that there is not a straight-forward relationship between how good/intense an expression is and how well it is recognized. Still, it would be interesting to investigate whether differences in the implementation of display rules played a role in how the two groups of posers produced emotional expressions, and in how those expressions were recognized.

Another possibility for why autistic expressions were recognized more accurately than non-autistic expressions in the studies reported here could be because the lived experiences of the autistic posers led them to have more practice making recognizable emotional expressions than the non-autistic posers. As mentioned in Study 3, many autistic people receive behavioral interventions when they are children. One study found that, in the US, nearly 64% of autistic children received some form of behavioral intervention (Xu et al., 2019). Often, a component of these interventions is social skills training, which often includes practicing and rehearsing facial emotional expressions (e.g., Gordon et al., 2014; Grossard et al., 2017, 2018; Hassan et al., 2021). These expressions typically are not naturally elicited, but rather posed, stereotyped expressions which are rewarded by the behavioral interventionist when they appear “correct.” Here, “correct” expressions are likely to mean those that include all of the components non-autistic people expect an expression of a given emotion to include (e.g., they might expect an expression of happiness to feature an open, toothy smile with crinkled corners of the eyes).

Similarly, many autistic people report engaging in camouflaging behaviors: behaviors intended to “hide” the fact that they are autistic by behaving in non-autistic ways (Dell’Osso et al., 2021; Hull et al., 2017). Often, autistic people report engaging in these behaviors because of the stigma they perceive when they do not try to hide their autistic-like behaviors (Hull et al., 2017; Pearson & Rose, 2021; Perry et al., 2022). This means that camouflaging behaviors are aimed at making the autistic person outwardly appear as a non-autistic person. Autistic people report sometimes rehearsing facial expressions so that they will look the way non-autistic people expect them to look (e.g., Bargiela et al., 2016; Hull et al., 2017). If the autistic posers in Brewer et al.'s (2016) stimulus set had engaged in camouflaging behaviors as a response to autism-related stigma, that could mean they might have practiced making emotional expressions that were easily recognizable to non-autistic people, whereas the non-autistic posers likely had not done this.

As with the differences in the use of display rules, there is no way of knowing whether the autistic posers in Brewer et al.'s (2016) study received behavior interventions that required the practice of facial expressions, or if they engaged in camouflaging behaviors like practicing facial expressions. Likewise, there is no way of knowing whether these sorts of practice have an effect on the perceived quality or intensity of facial expressions. Nevertheless, one reason the autistic expressions may have been recognized more accurately could be because the autistic posers had much more experience in making recognizable expressions compared to the non-autistic posers.

Why Are Autistic People Misunderstood?

Studies 1-5 demonstrated that non-autistic people could accurately recognize the emotions in facial expressions produced by a sample of autistic adults—and in fact, they recognized them better than the expressions of non-autistic adults. Internal representations for emotional expressions are used in the production and interpretation for emotional expressions (e.g., Bird & Viding, 2014; Goldman & Sripada, 2005; Gola et al., 2017; Jack & Schyns, 2017). Given this, these results suggest that non-autistic people do not misunderstand autistic people's emotions because differences in internal representations for emotional expressions lead non-autistic people to mis-recognized autistic people's emotional expressions. So, what other explanations exist for why non-autistic people sometimes misunderstand autistic people's emotions? Below, I outline two possibilities: motor control or proprioceptive challenges and differences in what emotions are evoked in real-world situations.

Motor Control and Proprioceptive Feedback Difficulties

One possibility is that autistic people have internal representations for emotional expressions that are similar to those of non-autistic people, but in real-world situations, motor control and/or proprioceptive challenges prevent them from enacting those internal representations. Many autistic people have co-occurring difficulties with motor control (e.g., Bäckström et al., 2021; Gowen & Hamilton, 2013; Hughes, 1996; MacNeil & Mostofsky, 2012; Robledo et al., 2012; Schmitz et al., 2003). In particular, autistic people are more likely to experience these difficulties with fine motor movements (which involve muscles like those in the fingers or face) than are non-autistic people (e.g., Ming et al., 2007; Provost et al., 2007). This can mean that the bodies of autistic people do not always execute the motor actions that the person desires to complete, or those actions are not executed in the way they expected. For example, in one study that surveyed blogs written by autistic people, one blogger described that despite their intent to set a plate for every person at the dinner table, they ended up stacking plates and cups on separate ends of the table (Welch et al., 2021, p. 3162). They explained that they felt that their body engaged in behavior that they did not intend. Of course, setting a table is not the same as expressing an emotion with one’s face. But if the same sort of motor control difficulties are experienced by autistic people when forming facial expressions in real life, it is possible that they might make an expression that they did not intend to make.

Autistic people also experience difficulties with proprioceptive feedback–the signals from the body that create a feedback loop which lets us know whether we are completing an action in the intended manner (e.g., Blanche et al., 2012; Morris et al., 2015). If autistic people intend to make an expression of a certain emotion, but difficulties with motor control mean their face does not take the intended expression, *and* difficulties with proprioceptive feedback mean the autistic person is not aware their face looks differently than they intended, non-autistic people may misunderstand those expressions.

Indeed, recent evidence suggests that giving autistic people the opportunity to view their facial expressions as they produce them (thereby reducing the effects of difficulties with proprioceptive feedback) can have an effect on how accurately their expressions are recognized (Lampi et al., under review). Autistic and non-autistic posers from Brewer et al. (2016) also made expressions in a "mirror" condition in which they could view their expressions as they made them. As a result, they would not have to rely on proprioceptive feedback to know whether they had produced the expression they intended (and which presumably matched their internal representation of that expression). In this case, non-autistic participants did not consistently recognize autistic expressions better or worse than non-autistic expressions.[14] These results suggest that even when making posed emotional expressions, difficulty controlling the appearance of one's face, combined with the proprioceptive feedback regarding one's appearance, can affect how autistic people form their expressions. When these difficulties affect the production of emotional expressions in interactions with non-autistic people, misunderstandings may arise.

Unexpected Emotions

A second reason why non-autistic people may sometimes misunderstand autistic people's emotional experiences may not have to do directly with misunderstanding what an autistic

[14] Autistic expressions of disgust were recognized more accurately than non-autistic expressions, and non-autistic expressions of fear were recognized more accurately than autistic expressions. There was no difference between autistic and non-autistic expressions for the other four emotions.

person is feeling on the basis of their emotional expressions. Instead, non-autistic people may misunderstand an autistic person's experience of a certain emotion because autistic people sometimes experience different emotions than non-autistic people expect in response to the same event. Indeed, autistic adults describe non-autistic people's confusion when they (the autistic person) experience an emotion the non-autistic person does not feel is appropriate given the situation. For example, one autistic woman on social media described how she will chuckle or laugh in response to being yelled at or scolded, often to the bewilderment of her non-autistic interlocutors (@joswisdom). Another autistic man described that sometimes he feels emotions that are much stronger than non-autistic people expect him to feel given the events he had just encountered (The Aspie World, 2021). In one example, he described feeling much more upset about not having been able to go for a run one day than his non-autistic partner expected him to feel. Similarly, one autistic respondent in Robledo et al. (2012) reported feeling much greater amounts of anger than they perceived their non-autistic peers to experience.

In these examples, non-autistic people likely are not mistaking their autistic peers' facial expressions as signals of some other emotion. Instead, they are likely misunderstanding the autistic person's broader emotional experience, including why they are feeling a certain way and what caused them to experience that emotion. Situations such as this could still contribute to autistic people's feeling misunderstood by non-autistic people, even if non-autistic people can identify the specific emotional expression an autistic person is conveying. To place misunderstandings of this sort in the context of internal representations, rather than having different internal representations for the appearance of emotional expressions, autistic and non-autistic people might have different representations for what contexts are likely to elicit certain emotions.

This mismatch in expectations *for the emotions elicited in certain contexts* could explain, for instance, the findings of Sheppard et al. (2016), described in the Introduction. Recall that in that study, autistic and non-autistic participants were recorded while being exposed to one of several novel experiences. Non-autistic participants then later had more difficulty inferring what experience the autistic people had just encountered than the non-autistic people. One reason for this could be that the autistic people had different emotional reactions to those experiences than the non-autistic participants had expected, thus leading to the lower accuracy. One way to investigate whether autistic and non-autistic people have different expectations for the emotions that are associated with certain contexts is to present autistic and non-autistic people with different emotion-eliciting scenarios and ask them what emotion they would experience. If the two groups offer different responses, that would suggest that one reason autistic people feel misunderstood by non-autistic people is because the two groups sometimes experience different emotions in the same context.

Autistic people expressing emotion differently than they intend or experiencing emotions that non-autistic people do not expect are just two examples of the ways in which non-autistic people misunderstand autistic people's emotions in real interactions. I raise these possibilities, though, to illustrate the point that as the field progresses, future work must explore the many ways in which the dynamic, spontaneous expression of emotion can give rise to non-autistic peoples' misunderstanding of autistic people's emotions.

Limitations

There are at least four limitations of the studies reported here. First, I did not investigate responses of autistic participants to the non-autistic and autistic facial emotional expressions. As noted above, my primary interest was in whether differences in internal representations for emotional expressions could explain why non-autistic people misunderstand autistic people's emotions, and so using non-autistic participants to address this question was appropriate. Still, including a sample of autistic participants would have helped further our understanding of the bi-directional nature of cross-neurotype misunderstandings about emotion.

A second limitation of this work is that the studies conducted here used stimulus sets consisting of 12 autistic and 12 non-autistic people, raising questions about how generalizable the findings are. Of course, this is a limitation of any work that uses a sample of stimuli. But I would argue that stimuli from these 24 posers allowed me to answer the question I set out to address: Are differences in internal representations of emotion between autistic and non-autistic people a viable explanation for non-autistic people's misunderstanding autistic people's emotions? I have found that the emotional expressions produced by a sample of autistic adults (which I presume to reflect their internal representations) were consistently well recognized by several large samples of non-autistic adults. This means that differences in internal representations for the end-state of facial emotional expressions cannot explain why non-autistic people have difficulty understanding what autistic people are feeling.

A third limitation of this work is that the studies reported here used posed emotional expressions as stimuli. I used posed emotional expressions because they are good proxies for internal representations for emotional expressions (e.g., Binetti et al., 2022; Jack & Schyns, 2015) and because both Brewer et al. (2016) and Faso et al. (2015) used posed emotional expressions to investigate autistic and non-autistic people's internal representations. But there are also a number of drawbacks to posed facial emotional expressions. For example, posed emotional expressions are not a perfect analog for how emotions look in real-life interactions. Posed expressions are often stereotypical or caricatured, while spontaneous emotional expressions are more nuanced, meaning expressions of the same emotion may have different features depending on the context in which they are expressed (e.g., Mau et al., 2021). This could be one reason why people have more difficulty accurately recognizing spontaneous expressions compared to posed expressions (Krumhuber et al., 2019). As a result, the expressions used in these studies would not always reflect how the posers might express emotion naturally.

Relatedly, the interpretation of posed emotional expressions can be highly context-dependent (e.g., Aviezer et al., 2007; Barrett et al., 2007; Barrett et al., 2011; Barrett, 2022). In one study, for example, Carroll and Russell (1996) presented participants with posed expressions of emotion—such as sadness—but told them an accompanying story that suggested the expression might show a different emotional state—like disgust. Participants tended to indicate the face showed the emotion implied by the story rather than the one the face was supposed to convey when the poser initially made the expression. In my studies, participants were not exposed to any accompanying context—congruent or incongruent—with the expressions they recognized or rated. Nevertheless, other contextual factors, such as their own emotional states or the emotions expressed in their most recent interactions (e.g., Robinson & Clore, 2002), may have influenced their performance on these tasks.

A fourth limitation of this work is that how participants interpreted the posed expressions may have been influenced by the particular emotion terms they could choose from. By forcing participants to choose from one of six different emotion categories, I may have artificially created agreement among participants (Barrett, 2022). For example, if they had been given the opportunity to offer a free response, participants might have used different terms to describe the same expression. One participant may have perceived an expression as showing "frustration," while another might describe it as showing "irritation." In an open response format, these would receive two different emotion labels, but when forced to choose from one of six emotions, both participants might select “anger.” In this way, using posed emotional expressions with forced choice responding might gloss over some of the nuance with which participants would otherwise perceive these faces.

Despite these limitations, posed emotional expressions were the best way for me to address whether differences in internal representations contributed to why non-autistic people sometimes misunderstand how autistic people are feeling. We cannot presume that these posed emotional expressions always look like real-life expressions, but they do provide insight into a given person’s expectations for how emotional states tend to look. Similarly, while context would certainly affect the interpretation of emotional expressions in the real world, my goal was to investigate internal representations for emotional expressions without context. Finally, while limiting participants’ responses to one of six emotion labels may have inhibited richer interpretation of the facial expressions, it allowed me to investigate how observers perceived the faces using the same categories the posers used when creating the expressions. In these ways, the posed stimuli I used here were appropriate for my goal of investigating autistic and non-autistic people’s internal representations.

Conclusions

This dissertation was motivated by experiences like those of one 40-year-old autistic woman, who said “I mean, my entire life I’ve been ‘weird.’ And I’ve never been someone who kind of fitted in. Because, I have always been that, you know, square peg in the round hole.” (Botha et al., 2022; p. 436). Feelings like these—where one senses that they don’t belong, or that they must change who they are in order to fit in—are an unfortunate reality for many autistic people. I believe that should change. To that end, the work included in this dissertation investigated one phenomenon that likely contributes to autistic people's feeling "weird:" having their emotions misunderstood by non-autistic people. More specifically, I asked whether differences in internal representations of emotional expressions lead non-autistic people to misunderstand autistic people's emotions.

My hope is that from this work, the reader will leave with two conclusions. The first is that over the five studies included in this dissertation, I have found that differences in internal representations do not explain why non-autistic people misunderstand autistic people's emotions. Of course, while it is encouraging to know that this is *not* a reason for autistic people's feeling like they don't belong, it means we still do not yet know what about their interactions with non-autistic people lead them to feel misunderstood. Therefore, the second conclusion I hope to leave with the reader is that this work, motivated and informed by the lived experiences of autistic people, must continue. By first characterizing how autistic people feel misunderstood by non-autistic people, and when these misunderstanding occur, we can design experiments that mimic the sorts of real-world misunderstandings described by autistic people. Doing so will allow us to understand the mechanisms that cause non-autistic people to misunderstand autistic people's emotions, which in turn will allow us to continue building a world where autistic people feel valued, welcomed, and included.

References

American Psychiatric Association [APA] (2013). *Diagnostic and Statistical Manual of Mental Disorders-5th Edition*. https://doi.org/https://doi.org/10.1176/appi.books.9780890425596

[@Autisong] (2021, April 7). *#stitch with @autisticqueen #autism #actuallyautistic #tourettes #neurotypicals #neurodivergent #stim #disabled #emotions* [Video]. TikTok. https://vm.tiktok.com/TTPdav6X6G/

Aviezer, H., Hassin, R. R., Ryan, J., Grady, C., Susskind, J., Anderson, A., Moscovitch, M. & Bentin, S. (2007). Angry, disgusted, or afraid? *Psychological Science*, *19*(7), 724–732. https://doi.org/10.1111/j.1467-9280.2008.02148.x

Bäckström, A., Johansson, A.-M., Rudolfsson, T., Rönnqvist, L., Hofsten, C. von, Rosander, K. & Domellöf, E. (2021). Motor planning and movement execution during goal-directed sequential manual movements in 6-year-old children with autism spectrum disorder: A kinematic analysis. *Research in Developmental Disabilities*, *115*, 104014. https://doi.org/10.1016/j.ridd.2021.104014

Bagby, R. M., Parker, J. D. A. & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia scale—I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, *38*(1), 23--32. https://doi.org/10.1016/0022-3999(94)90005-1

Bargiela, S., Steward, R. & Mandy, W. (2016). The experiences of late-diagnosed women with autism spectrum conditions: An investigation of the female autism phenotype. *Journal of Autism and Developmental Disorders*, *46*(10), 3281–3294. https://doi.org/10.1007/s10803-016-2872-8

Baron-Cohen, S., Jolliffe, T., Mortimore, C. & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry*, *38*(7), 813–822. https://doi.org/10.1111/j.1469-7610.1997.tb01599.x

Baron-Cohen, S., Leslie, A. M. & Frith, U. (1985). Does the autistic child have a "theory of mind" ? *Cognition*, *21*(1), 37-46. https://doi.org/10.1016/0010-0277(85)90022-8

Barrett, L. F. (2011). Was Darwin wrong about emotional expressions? *Current Directions in Psychological Science*, *20*(6), 400–406. https://doi.org/10.1177/0963721411429125

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social Cognitive and Affective Neuroscience*, *12*(1), 1–23. https://doi.org/10.1093/scan/nsw154

Barrett, L. F. (2022). Context reconsidered: Complex signal ensembles, relational meaning, and population thinking in psychological science. *American Psychologist*, *77*(8), 894–920. https://doi.org/10.1037/amp0001054

Barrett, L. F., Mesquita, B. & Gendron, M. (2011). Context in emotion perception. *Current Directions in Psychological Science*, *20*(5), 286–290. https://doi.org/10.1177/0963721411422522

Barrett, L. F., Mesquita, B., Ochsner, K. N. & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology*, *58*(1), 373–403. https://doi.org/10.1146/annurev.psych.58.110405.085709

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1-48. doi:10.18637/jss.v067.i01.

Begeer, S., Banerjee, R., Rieffe, C., Terwogt, M. M., Potharst, E., Stegge, H. & Koot, H. M.

(2011). The understanding and self-reported use of emotional display rules in children with autism spectrum disorders. *Cognition and Emotion*, *25*(5), 947–956. https://doi.org/10.1080/02699931.2010.516924

Berthoz, S. & Hill, E. L. (2005). The validity of using self-reports to assess emotion regulation abilities in adults with autism spectrum disorder. *European Psychiatry*, *20*(3), 291--298. https://doi.org/10.1016/j.eurpsy.2004.06.013

Bieberich, A. A. & Morgan, S. B. (2004). Self-regulation and affective expression during play in children with autism or Down syndrome: A short-term longitudinal study. *Journal of Autism and Developmental Disorders*, *34*(4), 439–448. https://doi.org/10.1023/b:jadd.0000037420.16169.28

Binetti, N., Roubtsova, N., Carlisi, C., Cosker, D., Viding, E. & Mareschal, I. (2022). Genetic algorithms reveal profound individual differences in emotion recognition. *Proceedings of the National Academy of Sciences*, *119*(45), e2201380119. https://doi.org/10.1073/pnas.2201380119

Bird, G. & Cook, R. (2013). Mixed emotions: the contribution of alexithymia to the emotional symptoms of autism. *Translational Psychiatry*, *3*(7), e285--e285. https://doi.org/10.1038/tp.2013.61

Bird, G., Silani, G., Brindley, R., White, S., Frith, U. & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain*, *133*(5), 1515-1525. https://doi.org/10.1093/brain/awq060

Bird, G. & Viding, E. (2014). The self to other model of empathy: Providing a new framework for understanding empathy impairments in psychopathy, autism, and alexithymia. *Neuroscience & Biobehavioral Reviews*, *47*, 520--532. https://doi.org/10.1016/j.neubiorev.2014.09.021

Blanche, E. I., Reinoso, G., Chang, M. C. & Bodison, S. (2012). Proprioceptive processing difficulties among children with autism spectrum disorders and developmental disabilities. *The American Journal of Occupational Therapy*, *66*(5), 621–624. https://doi.org/10.5014/ajot.2012.004234

Bölte, S. & Poustka, F. (2003). The recognition of facial affect in autistic and schizophrenic subjects and their first-degree relatives. *Psychological Medicine*, *33*(5), 907–915. https://doi.org/10.1017/s0033291703007438

Botha, M., Dibb, B. & Frost, D. M. (2022). "Autism is me": an investigation of how autistic individuals make sense of autism and stigma. *Disability & Society*, *37*(3), 427–453. https://doi.org/10.1080/09687599.2020.1822782

Botha, M. & Frost, D. M. (2020). Extending the minority stress model to understand mental health problems experienced by the autistic population. *Society and Mental Health*, *10*(1), 20–34. https://doi.org/10.1177/2156869318804297

Brewer, R., Biotti, F., Catmur, C., Press, C., Happé, F., Cook, R. & Bird, G. (2016). Can neurotypical individuals read autistic facial expressions? Atypical production of emotional facial expressions in autism spectrum disorders. *Autism Research : Official Journal of the International Society for Autism Research*, *9*(2), 262–271. https://doi.org/10.1002/aur.1508

Bury, S. M., Jellett, R., Spoor, J. R. & Hedley, D. (2020). "It defines who I am" or "It's something I have": What language do [autistic] Australian adults [on the autism spectrum] prefer? *Journal of Autism and Developmental Disorders*, 1–11. https://doi.org/10.1007/s10803-020-04425-3

Calvo, M. G. & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): Identification under different display-duration conditions. *Behavior Research Methods*, *40*(1), 109–115. https://doi.org/10.3758/brm.40.1.109

Camm-Crosbie, L., Bradley, L., Shaw, R., Baron-Cohen, S. & Cassidy, S. (2019). 'People like me don't get support': Autistic adults' experiences of support and treatment for mental health difficulties, self-injury and suicidality. *Autism*, *23*(6), 1431–1441. https://doi.org/10.1177/1362361318816053

Carroll, J. M. & Russell, J. A. (1996). Do facial expressions signal specific emotions? Judging emotion from the face in context. *Journal of Personality and Social Psychology*, *70*(2), 205–218. https://doi.org/10.1037/0022-3514.70.2.205

Chatterjee, S. (2012). *Regression Analysis By Example* (5th ed.). Wiley.

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S. & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in Cognitive Sciences*, *16*(4), 231–239. https://doi.org/10.1016/j.tics.2012.02.007

Clore, G. L. & Ortony, A. (1991). What more is there to emotion concepts than prototypes? *Journal of Personality and Social Psychology*, *60*(1), 48–50. https://doi.org/10.1037/0022-3514.60.1.48

Cohen, J. (1992). Quantitative methods in psychology: A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1038/141613a0

Cook, R., Brewer, R., Shah, P. & Bird, G. (2013). Alexithymia, not autism, predicts poor recognition of emotional facial expressions. *Psychological Science*, *24*(5), 723-732. https://doi.org/10.1177/0956797612463582

Couture, S. M., Penn, D. L., Losh, M., Adolphs, R., Hurley, R. & Piven, J. (2010). Comparison of social cognitive functioning in schizophrenia and high functioning autism: more convergence than divergence. *Psychological Medicine*, *40*(4), 569–579. https://doi.org/10.1017/s003329170999078x

Crompton, C. J., Hallett, S., Ropar, D., Flynn, E. & Fletcher-Watson, S. (2020). "I never realised everybody felt as happy as I do when I am around autistic people": A thematic analysis of autistic adults' relationships with autistic and neurotypical friends and family. *Autism: The International Journal of Research and Practice*, 1362361320908976. https://doi.org/10.1177/1362361320908976

Crompton, C. J., Ropar, D., Evans-Williams, C. V., Flynn, E. G. & Fletcher-Watson, S. (2020). Autistic peer-to-peer information transfer is highly effective. *Autism*, *24*(7), 1704–1712. https://doi.org/10.1177/1362361320919286

Czapinski, P. & Bryson, S. E. (2003). Reduced facial muscle movements in autism: Evidence for dysfunction in the neuromuscular pathway? *Brain and Cognition*, *51*, 177–179.

Dawson, G., Hill, D., Spencer, A., Galpert, L. & Watson, L. (1990). Affective exchanges between young autistic children and their mothers. *Journal of Abnormal Child Psychology*, *18*(3), 335–345. https://doi.org/10.1007/bf00916569

DeBrabander, K. M., Morrison, K. E., Jones, D. R., Faso, D. J., Chmielewski, M. & Sasson, N. J. (2019). Do first impressions of autistic adults differ between autistic and nonautistic observers? *Autism in Adulthood*, *1*(4), 250–257. https://doi.org/10.1089/aut.2019.0018

Dell'Osso, L., Cremone, I. M., Chiarantini, I., Arone, A., Massimetti, G., Carmassi, C. &

Carpita, B. (2022). Autistic traits and camouflaging behaviors: a cross-sectional investigation in a university student population. *CNS Spectrums*, *27*(6), 740–746. https://doi.org/10.1017/s1092852921000808

Dinishak, J. & Akhtar, N. (2013). A critical examination of mindblindness as a metaphor for autism. *Child Development Perspectives*, *7*(2), 110–114. https://doi.org/10.1111/cdep.12026

Eack, S. M., Mazefsky, C. A. & Minshew, N. J. (2015). Misinterpretation of facial expressions of emotion in verbal adults with autism spectrum disorder. *Autism*, *19*(3), 308--315. https://doi.org/10.1177/1362361314520755

Edey, R., Cook, J., Brewer, R., Johnson, M. H., Bird, G. & Press, C. (2016). Interaction takes two: Typical adults exhibit mind-blindness towards those with autism spectrum disorder. *Journal of Abnormal Psychology*, *125*(7), 879–885. https://doi.org/10.1037/abn0000199

Ekman, P. & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, *17*(2), 124–129. https://doi.org/10.1037/h0030377

Ekman, P. & Friesen, W. V. (1976). Measuring facial movement. *Environmental Psychology and Nonverbal Behavior*, *1*(1), 56–75. https://doi.org/10.1007/bf01115465

Ekman, P. & Friesen, W. (1978). *Facial action coding system: A technique for the measurement of facial movement*. Consulting Psychologists Press.

Ekman, P. & Friesen, W. V. (1986). A new pan-cultural facial expression of emotion. *Motivation and Emotion*, *10*(2), 159–168. https://doi.org/10.1007/bf00992253

Erdfelder, E., Faul, F. & Buchner, A. (1996). GPOWER: A general power analysis program. *Behavior Research Methods, Instruments, & Computers*, *28*(1), 1–11. https://doi.org/10.3758/bf03203630

Evers, K., Steyaert, J., Noens, I. & Wagemans, J. (2015). Reduced recognition of dynamic facial emotional expressions and emotion-specific response bias in children with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(6), 1774–1784. https://doi.org/10.1007/s10803-014-2337-x

Faso, D. J., Sasson, N. J. & Pinkham, A. E. (2015). Evaluating posed and evoked facial expressions of emotion from adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(1), 75–89. https://doi.org/10.1007/s10803-014-2194-7

Faul, F., Erdfelder, E., Lang, A.-G. & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Gendron, M., Crivelli, C. & Barrett, L. F. (2018). Universality reconsidered: Diversity in making meaning of facial expressions. *Current Directions in Psychological Science*, *27*(4), 211–219. https://doi.org/10.1177/0963721417746794

Gernsbacher, M. A. (2006). Toward a behavior of reciprocity. *The Journal of Developmental Processes*, *1*(1), 139–152.

Gernsbacher, M. A. (2017). Editorial Perspective: The use of person-first language in scholarly writing may accentuate stigma. *Journal of Child Psychology and Psychiatry*, *58*(7), 859--861. https://doi.org/10.1111/jcpp.12706

Gernsbacher, M. A. & Yergeau, M. (2019). Empirical failures of the claim that autistic people lack a theory of mind. *Archives of Scientific Psychology*, *7*(1), 102–118. https://doi.org/10.1037/arc0000067

Getz, G. E., Shear, P. K. & Strakowski, S. M. (2003). Facial affect recognition deficits in bipolar disorder. *Journal of the International Neuropsychological Society*, *9*(4), 623–632. https://doi.org/10.1017/s1355617703940021

Gnepp, J. & Hess, D. L. R. (1986). Children's understanding of verbal and facial display rules. *Developmental Psychology*, *22*(1), 103–108. https://doi.org/10.1037/0012-1649.22.1.103

Gola, K. A., Shany-Ur, T., Pressman, P., Sulman, I., Galeana, E., Paulsen, H., Nguyen, L., Wu, T., Adhimoolam, B., Poorzand, P., Miller, B. L. & Rankin, K. P. (2017). A neural network underlying intentional emotional facial expression in neurodegenerative disease. *NeuroImage: Clinical*, *14*, 672–678. https://doi.org/10.1016/j.nicl.2017.01.016

Goldman, A. I. & Sripada, C. S. (2005). Simulationist models of face-based emotion recognition. *Cognition*, *94*(3), 193–213. https://doi.org/10.1016/j.cognition.2004.01.005

Gordon, I., Pierce, M. D., Bartlett, M. S. & Tanaka, J. W. (2014). Training facial expression production in children on the autism spectrum. *Journal of Autism and Developmental Disorders*, *44*(10), 2486–2498. https://doi.org/10.1007/s10803-014-2118-6

Gowen, E. & Hamilton, A. (2013). Motor abilities in autism: A review using a computational context. *Journal of Autism and Developmental Disorders*, *43*(2), 323–344. https://doi.org/10.1007/s10803-012-1574-0

Green, P. & MacLeod, C. J. (2016). SIMR: an R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210x.12504

Grömping, U. (2007). Estimators of relative importance in linear regression based on variance decomposition. *The American Statistician*, *61*(2), 139–147. https://doi.org/10.1198/000313007x188252

Grossard, C., Palestra, G., Xavier, J., Chetouani, M., Grynszpan, O. & Cohen, D. (2018). ICT and autism care. *Current Opinion in Psychiatry*, *31*(6), 474–483. https://doi.org/10.1097/yco.0000000000000455

Grossard, C., Grynspan, O., Serret, S., Jouen, A.-L., Bailly, K. & Cohen, D. (2017). Serious games to teach social interactions and emotions to individuals with autism spectrum disorders (ASD). *Computers & Education*, *113*, 195–211. https://doi.org/10.1016/j.compedu.2017.05.002

Grossman, R. B. (2015). Judgments of social awkwardness from brief exposure to children with and without high-functioning autism. *Autism*, *19*(5), 580–587. https://doi.org/10.1177/1362361314536937

Grossman, R. B., Edelson, L. R. & Tager-Flusberg, H. (2013). Emotional facial and vocal expressions during story retelling by children and adolescents with high-functioning autism. *Journal of Speech, Language, and Hearing Research: JSLHR*, *56*(3), 1035–1044. https://doi.org/10.1044/1092-4388(2012/12-0067)

Grynberg, D., Chang, B., Corneille, O., Maurage, P., Vermeulen, N., Berthoz, S. & Luminet, O. (2012). Alexithymia and the processing of emotional facial expressions (EFEs): Systematic review, unanswered questions and further perspectives. *PLoS ONE*, *7*(8), e42429. https://doi.org/10.1371/journal.pone.0042429

Hassan, A., Pinkwart, N. & Shafi, M. (2021). Serious games to improve social and emotional intelligence in children with autism. *Entertainment Computing*, *38*, 100417. https://doi.org/10.1016/j.entcom.2021.100417

Heasman, B. & Gillespie, A. (2018). Perspective-taking is two-sided: Misunderstandings between people with Asperger's syndrome and their family members. *Autism*, *22*(6), 740–750. https://doi.org/10.1177/1362361317708287

Henrich, J., Heine, S. J. & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, *466*(7302), 29–29. https://doi.org/10.1038/466029a

Hill, E., Berthoz, S. & Frith, U. (2004). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of Autism and Developmental Disorders*, *34*(2), 229--235. https://doi.org/10.1023/b:jadd.0000022613.41399.14

Hubbard, R. & Armstrong, J. S. (1997). Publication bias against null results. *Psychological Reports*, *80*(1), 337–338. https://doi.org/10.2466/pr0.1997.80.1.337

Hughes, C. (1996). Brief report: Planning problems in autism at the level of motor control. *Journal of Autism and Developmental Disorders*, *26*(1), 99–107. https://doi.org/10.1007/bf02276237

Hull, L., Petrides, K. V., Allison, C., Smith, P., Baron-Cohen, S., Lai, M.-C. & Mandy, W. (2017). "Putting on my best normal": Social camouflaging in adults with autism spectrum conditions. *Journal of Autism and Developmental Disorders*, *47*(8), 2519–2534. https://doi.org/10.1007/s10803-017-3166-5

Hurley, R. S. E., Losh, M., Parlier, M., Reznick, J. S. & Piven, J. (2007). The broad autism phenotype questionnaire. *Journal of Autism and Developmental Disorders*, *37*(9), 1679–1690. https://doi.org/10.1007/s10803-006-0299-3

Isomura, T., Ogawa, S., Yamada, S., Shibasaki, M. & Masataka, N. (2014). Preliminary evidence that different mechanisms underlie the anger superiority effect in children with and without autism spectrum disorders. *Frontiers in Psychology*, *5*, 461. https://doi.org/10.3389/fpsyg.2014.00461

Jack, R. E. (2013). Culture and facial expressions of emotion. *Visual Cognition*, *21*(9–10), 1–39.

https://doi.org/10.1080/13506285.2013.835367

Jack, R. E., Blais, C., Scheepers, C., Schyns, P. G. & Caldara, R. (2009). Cultural confusions show that facial expressions are not universal. *Current Biology*, *19*(18), 1543–1548. https://doi.org/10.1016/j.cub.2009.07.051

Jack, R. E., Caldara, R. & Schyns, P. G. (2012). Internal representations reveal cultural diversity in expectations of facial expressions of emotion. *Journal of Experimental Psychology: General*, *141*(1), 19–25. https://doi.org/10.1037/a0023463

Jack, R. E., Garrod, O. G. B., Yu, H., Caldara, R. & Schyns, P. G. (2012). Facial expressions of emotion are not culturally universal. *Proceedings of the National Academy of Sciences*, *109*(19), 7241–7244. https://doi.org/10.1073/pnas.1200155109

Jack, R. E. & Schyns, P. G. (2015). The human face as a dynamic tool for social communication. *Current Biology*, *25*(14), R621–R634. https://doi.org/10.1016/j.cub.2015.05.052

Jack, R. E. & Schyns, P. G. (2017). Toward a social psychophysics of face communication. *Annual Review of Psychology*, *68*(1), 269–297. https://doi.org/10.1146/annurev-psych-010416-044242

Jaswal, V. K. & Akhtar, N. (2018). Being versus appearing socially uninterested: Challenging assumptions about social motivation in autism. *Behavioral and Brain Sciences*, *42*, 1–84. https://doi.org/10.1017/s0140525x18001826

Jongen, S., Axmacher, N., Kremers, N. A. W., Hoffmann, H., Limbrecht-Ecklundt, K., Traue, H. C. & Kessler, H. (2014). An investigation of facial emotion recognition impairments in alexithymia and its neural correlates. *Behavioural Brain Research*, *271*, 129–139. https://doi.org/10.1016/j.bbr.2014.05.069

[@joswisdom] (2022, April 12). *emotions #actuallyautistic #autiatictiktok #autismoftiktok*

#autisticwomen #autismemotions #latediagnosedautistic #autisticexperience #autisticcreator [Video]. TikTok. https://www.tiktok.com/t/ZTdnPPCnt/?k=1

Kadak, M. T., Demirel, Ö. F., Yavuz, M. & Demir, T. (2014). Recognition of emotional facial expressions and broad autism phenotype in parents of children diagnosed with autistic spectrum disorder. *Comprehensive Psychiatry*, *55*(5), 1146–1151. https://doi.org/10.1016/j.comppsych.2014.03.004

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, *2*, 217–250.

Kaplan, H. B. & Liu, X. (2000). Social movements as collective coping with spoiled personal identities: Intimations from a panel study of changes in the life course between adolescence and adulthood. In S. Stryker, T. J. Owens & R. W. White (Eds.), *Self, Identity, and Social Movements* (pp. 215–238). University of Minnesota Press.

Kasari, C., Sigman, M., Mundy, P. & Yirmiya, N. (1990). Affective sharing in the context of joint attention interactions of normal, autistic, and mentally retarded children. *Journal of Autism and Developmental Disorders*, *20*(1), 87–100. https://doi.org/10.1007/bf02206859

Keating, C. T., Sowden, S. & Cook, J. L. (2022). Comparing internal representations of facial expression kinematics between autistic and non-autistic adults. *Autism Research*. https://doi.org/10.1002/aur.2642

Kenny, L., Hattersley, C., Molins, B., Buckley, C., Povey, C. & Pellicano, E. (2015). Which terms should be used to describe autism? Perspectives from the UK autism community. *Autism: The International Journal of Research and Practice*, *20*(4), 442–462. https://doi.org/10.1177/1362361315588200

Ketelaars, M. P., Velt, A. I., Mol, A., Swaab, H. & Rijn, S. van. (2016). Emotion recognition and alexithymia in high functioning females with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *21*, 51-60. https://doi.org/10.1016/j.rasd.2015.09.006

Kliemann, D., Dziobek, I., Hatri, A., Baudewig, J. & Heekeren, H. R. (2012). The role of the amygdala in atypical gaze on emotional faces in autism spectrum disorders. *Journal of Neuroscience*, *32*(28), 9469–9476. https://doi.org/10.1523/jneurosci.5294-11.2012

Knott, F., Dunlop, A.-W. & Mackay, T. (2006). Living with ASD. *Autism*, *10*(6), 609–617. https://doi.org/10.1177/1362361306068510

Konstantareas, M. M. & Hewitt, T. (2001). Autistic disorder and schizophrenia: Diagnostic overlaps. *Journal of Autism and Developmental Disorders*, *31*(1), 19–28. https://doi.org/10.1023/a:1005605528309

Krumhuber, E. G., Küster, D., Namba, S., Shah, D. & Calvo, M. G. (2019). Emotion recognition from posed and spontaneous dynamic expressions: Human observers versus machine analysis. *Emotion*, *21*(2), 447–451. https://doi.org/10.1037/emo0000712

Lampi, A. J., Brewer, R., Bird, G., Jaswal, V.K. (2023). Non-autistic adults can recognize posed autistic facial expressions: Implications for Internal Representations of Emotion. Manuscript under review.

Lane, R. D., Lee, S., Reidel, R., Weldon, V., Kaszniak, A. & Schwartz, G. E. (1996). Impaired verbal and nonverbal emotion recognition in alexithymia. *Psychosomatic Medicine*, *58*(3), 203–210. https://doi.org/10.1097/00006842-199605000-00002

Leadbitter, K., Buckle, K. L., Ellis, C. & Dekker, M. (2021). Autistic self-advocacy and the neurodiversity movement: Implications for autism early intervention research and practice. *Frontiers in Psychology*, *12*, 635690. https://doi.org/10.3389/fpsyg.2021.635690

Lenth, R. V. (2022). emmeans: Estimated marginal means, aka least-squares means. R package version 1.7.2. https://CRAN.R-project.org/package=emmeans

Leung, F. Y. N., Sin, J., Dawson, C., Ong, J. H., Zhao, C., Veić, A. & Liu, F. (2022). Emotion recognition across visual and auditory modalities in autism spectrum disorder: A systematic review and meta-analysis. *Developmental Review*, *63*, 101000. https://doi.org/10.1016/j.dr.2021.101000

Lombardo, M. V., Barnes, J. L., Wheelwright, S. J. & Baron-Cohen, S. (2007). Self-referential cognition and rmpathy in Autism. *PLoS ONE*, *2*(9), e883. https://doi.org/10.1371/journal.pone.0000883

Lord, C. & MaGill-Evans, J. (1995). Peer interactions of autistic children and adolescents. *Development and Psychopathology*, *7*(4), 611–626. https://doi.org/10.1017/s095457940000674x

Lozier, L. M., Vanmeter, J. W. & Marsh, A. A. (2014). Impairments in facial affect recognition associated with autism spectrum disorders: A meta-analysis. *Development and Psychopathology*, *26*, 933–945. https://doi.org/10.1017/s0954579414000479

MacNeil, L. K. & Mostofsky, S. H. (2012). Specificity of dyspraxia in children with autism. *Neuropsychology*, *26*(2), 165–171. https://doi.org/10.1037/a0026955

Malatesta, C. Z. & Haviland, J. M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development*, *53*(4), 991–1003. https://doi.org/10.1111/j.1467-8624.1982.tb01363.x

Manfredonia, J., Bangerter, A., Manyakov, N. V., Ness, S., Lewin, D., Skalkin, A., Boice, M., Goodwin, M. S., Dawson, G., Hendren, R., Leventhal, B., Shic, F. & Pandina, G. (2019). Automatic recognition of posed facial expression of emotion in individuals with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *49*(1), 279–293. https://doi.org/10.1007/s10803-018-3757-9

Markovska-Simoska, S. & Pop-Jordanova, N. (2010). Face and emotion recognition by ADHD and normal adults. *Acta Neuropsychologica*, *8*(2), 99–122.

Matsumoto, D. (1990). Cultural similarities and differences in display rules. *Motivation and Emotion*, *14*(3), 195–214. https://doi.org/10.1007/bf00995569

Matsumoto, D. (1992). More evidence for the universality of a contempt expression. *Motivation and Emotion*, *16*(4), 363–368. https://doi.org/10.1007/bf00992972

Matsumoto, D. (1993). Ethnic differences in affect intensity, emotion judgments, display rule attitudes, and self-reported emotional expression in an American sample. *Motivation and Emotion*, *17*(2), 107–123. https://doi.org/10.1007/bf00995188

Matsumoto, D., Yoo, S. H. & Fontaine, J. (2008). Mapping expressive differences around the world. *Journal of Cross-Cultural Psychology*, *39*(1), 55–74. https://doi.org/10.1177/0022022107311854

Mau, T. L., Hoemann, K., Lyons, S. H., Fugate, J. M. B., Brown, E. N., Gendron, M. & Barrett, L. F. (2021). Professional actors demonstrate variability, not stereotypical expressions, when portraying emotional states in photographs. *Nature Communications*, *12*(1), 5037. https://doi.org/10.1038/s41467-021-25352-6

Midi, H., & Bagheri, A. (2010, July). Robust multicollinearity diagnostic measure in collinear data set. *In Proceedings of the 4th international conference on applied mathematics, simulation, modeling* (pp. 138-142). World Scientific and Engineering Academy and Society (WSEAS).

Milosavljevic, B., Leno, V. C., Simonoff, E., Baird, G., Pickles, A., Jones, C. R. G., Erskine, C., Charman, T. & Happé, F. (2016). Alexithymia in adolescents with autism spectrum disorder: Its relationship to internalising difficulties, sensory modulation and social cognition. *Journal of Autism and Developmental Disorders*, *46*(4), 1354--1367. https://doi.org/10.1007/s10803-015-2670-8

Milton, D. E. M. (2012). On the ontological status of autism: the 'double empathy problem.' *Disability & Society*, *27*(6), 883–887. https://doi.org/10.1080/09687599.2012.710008

Ming, X., Brimacombe, M. & Wagner, G. C. (2007). Prevalence of motor impairment in autism spectrum disorders. *Brain and Development*, *29*(9), 565–570. https://doi.org/10.1016/j.braindev.2007.03.002

Montagne, B., Kessels, R. P. C., Haan, E. H. F. D. & Perrett, D. I. (2007). The emotion recognition task: A paradigm to measure the perception of facial emotional expressions at different intensities. *Perceptual and Motor Skills*, *104*(2), 589–598. https://doi.org/10.2466/pms.104.2.589-598

Morris, S. L., Foster, C. J., Parsons, R., Falkmer, M., Falkmer, T. & Rosalie, S. M. (2015). Differences in the use of vision and proprioception for postural control in autism spectrum disorder. *Neuroscience*, *307*, 273–280. https://doi.org/10.1016/j.neuroscience.2015.08.040

Nagy, E., Prentice, L. & Wakeling, T. (2021). Atypical facial emotion recognition in children with autism spectrum disorders: Exploratory analysis on the role of task demands. *Perception*, *50*(9), 819–833. https://doi.org/10.1177/03010066211038154

Nario-Redmond, M. R., Noel, J. G. & Fern, E. (2012). Redefining disability, re-imagining the self: Disability identification predicts self-esteem and strategic responses to stigma. *Self and Identity*, *12*(5), 1–21. https://doi.org/10.1080/15298868.2012.681118

Nario-Redmond, M. R. & Oleson, K. C. (2016). Disability group identification and disability-rights advocacy. *Emerging Adulthood*, *4*(3), 207–218. https://doi.org/10.1177/2167696815579830

Nemiah, J. C. & Sifneos, P. E. (1970). Psychosomatic illness: A problem in communication. *Psychotherapy and Psychosomatics*, *18*(1), 154--160. https://doi.org/10.1159/000286074

Niedenthal, P. M. (2007a). Emotion Concepts. In M. Lewis, J. M. Haviland-Jones & L. F. Barrett (Eds.), *Handbook of Emotions* (pp. 587–600). The Guilford Press.

Niedenthal, P. M. (2007b). Embodying Emotion. *Science*, *316*(5827), 1002–1005. https://doi.org/10.1126/science.1136930

Orgeta, V. & Phillips, L. H. (2007). Effects of age and emotional intensity on the recognition of facial emotion. *Experimental Aging Research*, *34*(1), 63–79. https://doi.org/10.1080/03610730701762047

Ortony, A., Clore, G. L. & Collins, A. (1988). *The Cognitive Structure of Emotions*. 34–58. https://doi.org/10.1017/cbo9780511571299.004

Otsuka, S., Uono, S., Yoshimura, S., Zhao, S. & Toichi, M. (2017). Emotion perception mediates the predictive relationship between verbal ability and functional outcome in high-functioning adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *47*(4), 1166–1182. https://doi.org/10.1007/s10803-017-3036-1

Palermo, M. T., Pasqualetti, P., Barbati, G., Intelligente, F. & Rossini, P. M. (2006). Recognition of schematic facial displays of emotion in parents of children with autism. *Autism*, *10*(4), 353–364. https://doi.org/10.1177/1362361306064431

Pearson, A. & Rose, K. (2021). A conceptual analysis of autistic masking: Understanding the narrative of stigma and the illusion of choice. *Autism in Adulthood*, *3*(1), 52–60. https://doi.org/10.1089/aut.2020.0043

Perry, E., Mandy, W., Hull, L. & Cage, E. (2022). Understanding camouflaging as a response to autism-related stigma: A social identity theory approach. *Journal of Autism and Developmental Disorders*, *52*, 800–810. https://doi.org/10.1007/s10803-021-04987-w

Peterson, C. C., Slaughter, V. P. & Paynter, J. (2007). Social maturity and theory of mind in typically developing children and those on the autism spectrum. *Journal of Child Psychology and Psychiatry*, *48*(12), 1243–1250. https://doi.org/10.1111/j.1469-7610.2007.01810.x

Piven, J., Palmer, P., Jacobi, D., Childress, D. & Arndt, S. (1997). Broader autism phenotype: evidence from a family history study of multiple-incidence autism families. *American Journal of Psychiatry*, *154*(2), 185–190. https://doi.org/10.1176/ajp.154.2.185

posit. (2022). RStudio. https://posit.co/

Provost, B., Heimerl, S. & Lopez, B. R. (2007). Levels of gross and fine motor development in young children with autism spectrum disorder. *Physical & Occupational Therapy In Pediatrics*, *27*(3), 21–36. https://doi.org/10.1080/j006v27n03_03

R Core Team. (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org/

Robinson, M. D. & Clore, G. L. (2002). Belief and feeling: Evidence for an accessibility model of emotional self-report. *Psychological Bulletin*, *128*(6), 934–960. https://doi.org/10.1037/0033-2909.128.6.934

Robison, J. E. (2011). *Be different: Adventures of a free-range Aspergian*. Doubleday Canada.

Robledo, J., Donnellan, A. M. & Strandt-Conroy, K. (2012). An exploration of sensory and movement differences from the perspective of individuals with autism. *Frontiers in Integrative Neuroscience*, *6*, 1–13. https://doi.org/10.3389/fnint.2012.00107

Russell, J. A. (1991). In defense of a prototype approach to emotion concepts. *Journal of Personality and Social Psychology*, *60*(1), 37–47. https://doi.org/10.1037/0022-3514.60.1.37

Saarni, C. (1979). Children's understanding of display rules for expressive behavior. *Developmental Psychology*, *15*(4), 424–429. https://doi.org/10.1037/0012-1649.15.4.424

Safdar, S., Friedlmeier, W., Matsumoto, D., Yoo, S. H., Kwantes, C. T., Kakai, H. & Shigemasu, E. (2009). Variations of emotional display rules within and across cultures: A comparison between Canada, USA, and Japan. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement*, *41*(1), 1–10. https://doi.org/10.1037/a0014387

Sasson, N. J., Faso, D. J., Nugent, J., Lovell, S., Kennedy, D. P. & Grossman, R. B. (2017). Neurotypical peers are less willing to interact with those with autism based on thin slice judgments. *Scientific Reports*, *7*(1), 40700. https://doi.org/10.1038/srep40700

Schmitz, C., Martineau, J., Barthélémy, C. & Assaiante, C. (2003). Motor control and children with autism: Deficit of anticipatory function? *Neuroscience Letters*, *348*(1), 17–20. https://doi.org/10.1016/s0304-3940(03)00644-x

Senju, A., Southgate, V., White, S. & Frith, U. (2009). Mindblind eyes: An absence of spontaneous theory of mind in Asperger syndrome. *Science*, *325*(5942), 883–885. https://doi.org/10.1126/science.1176170

Sheppard, E., Pillai, D., Wong, G. T.-L., Ropar, D. & Mitchell, P. (2016). How easy is it to read the minds of people with autism spectrum disorder? *Journal of Autism and Developmental Disorders*, *46*(4), 1247–1254. https://doi.org/10.1007/s10803-015-2662-8

Sivathasan, S., Fernandes, T. P., Burack, J. A. & Quintin, E.-M. (2020). Emotion processing and autism spectrum disorder: A review of the relative contributions of alexithymia and verbal IQ. *Research in Autism Spectrum Disorders*, *77*, 101608. https://doi.org/10.1016/j.rasd.2020.101608

Sonneville, L. M. J. D., Verschoor, C. A., Njiokiktjien, C., Veld, V. O. het, Toorenaar, N. & Vranken, M. (2002). Facial identity and facial emotions: Speed, accuracy, and processing strategies in children and adults. *Journal of Clinical and Experimental Neuropsychology (Neuropsychology, Development and Cognition: Section A)*, *24*(2), 200–213. https://doi.org/10.1076/jcen.24.2.200.989

Sowden, S., Schuster, B. A., Keating, C. T., Fraser, D. S. & Cook, J. L. (2021). The role of movement kinematics in facial emotion expression production and recognition. *Emotion*. https://doi.org/10.1037/emo0000835

Stagg, S. D., Slavny, R., Hand, C., Cardoso, A. & Smith, P. (2014). Does facial expressivity count? How typically developing children respond initially to children with autism. *Autism*, *18*(6), 704–711. https://doi.org/10.1177/1362361313492392

Sucksmith, E., Allison, C., Baron-Cohen, S., Chakrabarti, B. & Hoekstra, R. A. (2013). Empathy and emotion recognition in people with autism, first-degree relatives, and controls. *Neuropsychologia*, *51*(1), 98–105. https://doi.org/10.1016/j.neuropsychologia.2012.11.013

Taboas, A., Doepke, K. & Zimmerman, C. (2022). Short report: Preferences for identity-first versus person-first language in a US sample of autism stakeholders. *Autism*, 136236132211308. https://doi.org/10.1177/13623613221130845

Tamir, M. & Bigman, Y. E. (2018). Expectations influence how emotions shape behavior. *Emotion*, *18*(1), 15–25. https://doi.org/10.1037/emo0000351

The Aspie World. (2021, April 29) *AUTISM Faces - [Why YOU Don't Show Emotion]* [Video]. Youtube. https://www.youtube.com/watch?v=ei2Xhq8dPAA

Tracy, J. L. & Robins, R. W. (2008). The automaticity of emotion recognition. *Emotion*, *8*(1), 81–95. https://doi.org/10.1037/1528-3542.8.1.81

Tracy, J. L., Robins, R. W., Schriber, R. A. & Solomon, M. (2011). Is emotion recognition impaired in individuals with autism spectrum disorders? *Journal of Autism and Developmental Disorders*, *41*(1), 102–109. https://doi.org/10.1007/s10803-010-1030-y

Travis, L. L. & Sigman, M. (1998). Social deficits and interpersonal relationships in autism. *Mental Retardation and Developmental Disabilities: Research Reviews*, *4*, 65–72. https://doi.org/https://doi.org/10.1002/(SICI)1098-2779(1998)4:2<65::AID-MRDD2>3.0.CO;2-W

Tseng, H.-H., Huang, Y.-L., Chen, J.-T., Liang, K.-Y., Lin, C.-C. & Chen, S.-H. (2017). Facial and prosodic emotion recognition in social anxiety disorder. *Cognitive Neuropsychiatry*, *22*(4), 1–15. https://doi.org/10.1080/13546805.2017.1330190

Uljarevic, M. & Hamilton, A. (2013). Recognition of emotions in autism: A formal meta-analysis. *Journal of Autism and Developmental Disorders*, *43*(7), 1517--1526. https://doi.org/10.1007/s10803-012-1695-5

Wagner, H. L. (1993). On measuring performance in category judgment studies of nonverbal behavior. *Journal of Nonverbal Behavior*, *17*(1), 3–28. https://doi.org/10.1007/bf00987006

Weiss, M. J. & Harris, S. L. (2001). Teaching social skills to people with autism. *Behavior Modification*, *25*(5), 785–802. https://doi.org/10.1177/0145445501255007

Welch, C., Cameron, D., Fitch, M. & Polatajko, H. (2021). Living in autistic bodies: Bloggers discuss movement control and arousal regulation. *Disability and Rehabilitation*, *43*(22), 3159–3167. https://doi.org/10.1080/09638288.2020.1729872

Xu, G., Strathearn, L., Liu, B., O'Brien, M., Kopelman, T. G., Zhu, J., Snetselaar, L. G. & Bao, W. (2019). Prevalence and treatment patterns of autism spectrum disorder in the United States, 2016. *JAMA Pediatrics*, *173*(2), 153–159. https://doi.org/10.1001/jamapediatrics.2018.4208

Yeung, M. K. (2021). A systematic review and meta-analysis of facial emotion recognition in autism spectrum disorder: The specificity of deficits and the role of task characteristics. *Neuroscience & Biobehavioral Reviews*, *133*, 104518. https://doi.org/10.1016/j.neubiorev.2021.104518

Zeman, J. & Garber, J. (1996). Display rules for anger, sadness, and pain: It depends on who is watching. *Child Development*, *67*(3), 957–973. https://doi.org/10.1111/j.1467-8624.1996.tb01776.x

Appendix A: Study 1

Comparison of Emotion Recognition "First try" data vs. "Second Try" data

As mentioned in Study 1, in addition to collecting participant's first responses to the emotion recognition prompt for each image, I also allowed them to make a second choice. I wanted to analyze whether participants' average recognition accuracy improved as a result of having this additional opportunity to make a selection. To accomplish this, for each participant, I calculated their average recognition accuracy score within each poser neurotype for each emotion category, for both their first and second attempts. Recognition accuracy for the first attempt was the proportion of trials participants correctly identified the emotion on the first time seeing a displayed face. Recognition accuracy for the second attempt was calculated as the proportion of trials participants correctly identified the emotion on either the first or second time seeing a face. For example, for the 12 images of autistic posers displaying anger, on their first attempt, a given participant may have correctly indicated "anger" for 8 of those 12 images. This would yield an average recognition accuracy score of 0.75. That participant may also have indicated anger as their second choice for two of the four images they incorrectly identified on their first attempt. This would then mean that for trials inclusive of their first and second attempt, the participant correctly selected anger for 10 of 12 images, yielding a recognition accuracy score of 0.83.

To investigate whether participants' scores increased as a result of having this second opportunity, and to determine whether this increase was different for autistic or non-autistic expressions or whether it varied by emotion, I conducted a 2 (response attempt: first or second) x 2 (poser neurotype: autistic or non-autistic) x 6 (emotion: anger, disgust, fear, happiness, sadness, surprise) ANOVA. Figure A1 shows the results of this analysis. As is apparent in the figure, participants' recognition accuracy generally increased as a result of being given a second opportunity. What may not be immediately apparent is that this effect depended on the emotion shown and the neurotype of the poser. There was a significant three-way interaction between response attempt, poser neurotype, and emotion $F(5, 8510) = 6.87$, $p < .001$.

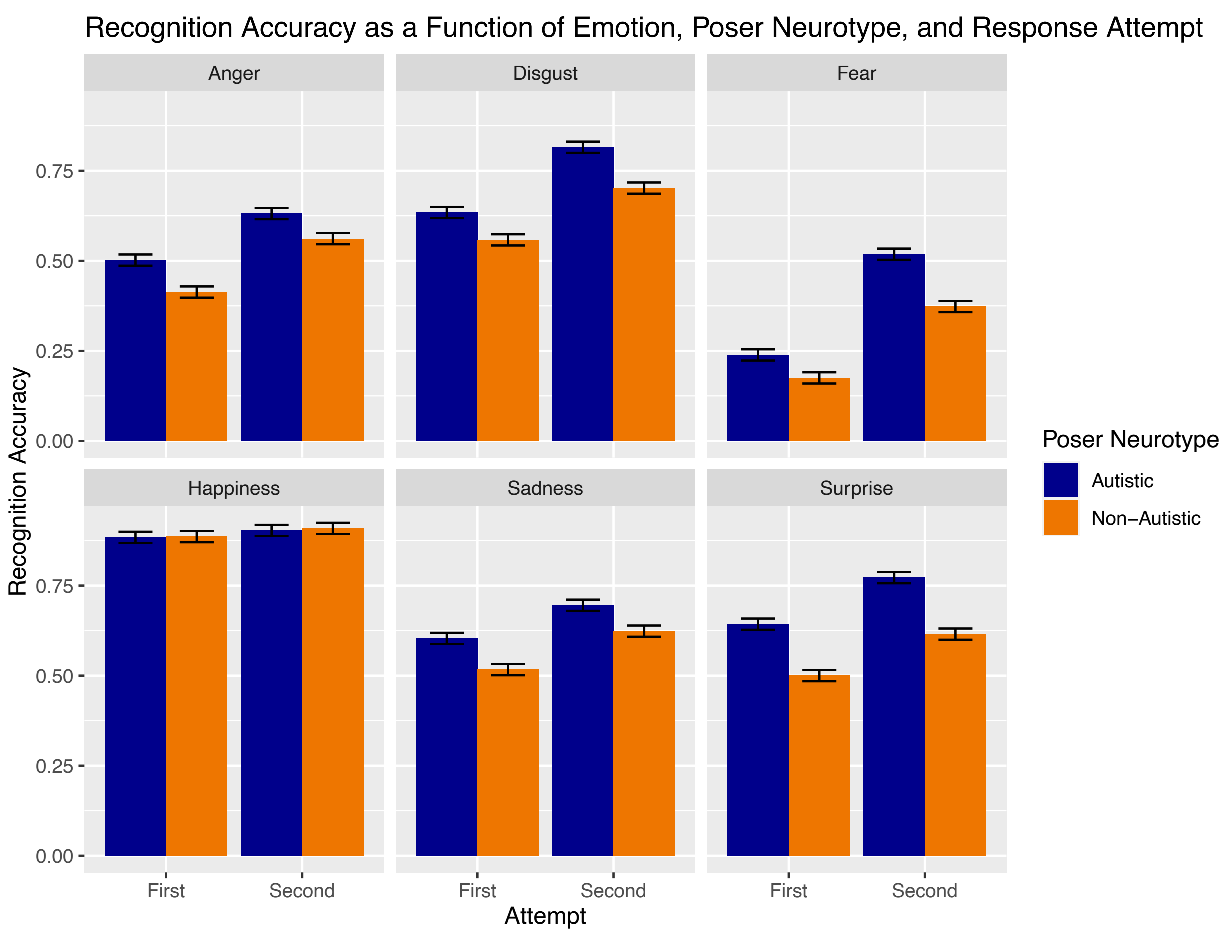

Figure A1. Emotion recognition accuracy as a function of emotion, poser neurotype, and response attempt. Error bars represent the 95% confidence interval.

To follow up on this interaction, I investigated the effect of the two-way interaction between poser neurotype and response attempt for each emotion. This two way interaction was significant for expressions of disgust, $F(1, 8510) = 6.59$, $p = .010$, and fear, $F(1, 8510) = 31.12$, $p < .001$, but was not significant for anger, happiness, sadness, or surprise. This pattern indicates that the increase in recognition accuracy as a result of the second opportunity to respond was uniform for autistic and non-autistic expressions of anger, happiness, sadness, and surprise. But, for expressions of disgust and fear, the change in recognition accuracy for autistic expressions was greater than it was for non-autistic expressions. The mean recognition accuracy rates for second-attempt responses to autistic and non-autistic posers can be found in Table A1, and can be contrasted with the recognition rates for the first attempt responses in Table A2.

Table A1.

Average Second-Attempt Recognition Accuracy for Autistic and Non-Autistic Posers by Emotion (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(8510)	Effect Size [95% CI]
Anger	.63 (.17)	.56 (.18)	6.74***	0.49 [0.35, 0.64]
Disgust	.82 (.14)	.70 (.13)	10.98***	0.81 [0.66, 0.95]
Fear	.52 (.18)	.37 (.17)	14.06***	1.03 [0.89, 1.18]
Happiness	.90 (.12)	.91 (.10)	0.57	-0.04 [-0.19, 0.10]
Sadness	.70 (.14)	.62 (.18)	6.95***	0.51 [0.37. 0.66]
Surprise	.77 (.12)	.62 (.13)	15.17***	1.11 [0.97, 1.26]

Note. Effect size was calculated using “emmeans” package in R (Lenth, 2022), it should be interpreted equivalently to Cohen’s D. ***$p < .001$.

Pairwise Comparisons in Emotion Recognition Accuracy

Table A2 shows the pairwise comparisons in recognition accuracy between autistic and non-autistic expressions for each of the six emotion categories from Study 1 .

Table A2.

Study 1 Average Recognition Accuracy for Autistic and Non-Autistic Posers by Emotion (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(4070)	Effect Size
Anger	.50 (.18)	.41 (.16)	8.21***	0.60
Disgust	.63 (.17)	.56 (.15)	7.02***	0.52
Fear	.24 (.17)	.17 (.14)	5.90***	0.43
Happiness	.88 (.13)	.89 (.11)	-0.19	-0.01
Sadness	.60 (.15)	.52 (.17)	8.02***	0.59
Surprise	.64 (.15)	.50 (.16)	13.21***	0.97

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022); it should be interpreted equivalently to Cohen's D. ***$p < .001$.

Poser Rank Correlation Matrix

Within each emotion category, I calculated where each poser ranked amongst the full sample of 24 posers in terms of recognition accuracy. Table A3 shows the correlation matrix for these poser rankings across the six emotions.

Table A3.

Spearman's Correlation for Poser Rank in Study 1 Across the Six Emotion Categories

	Anger	Disgust	Fear	Happiness	Sadness	Surprise
Anger	1.00					
Disgust	.06	1.00				
Fear	.33	.29	1.00			
Happiness	.15	.11	.11	1.00		
Sadness	.38	-.19	.25	.07	1.00	
Surprise	.50	.25	.43	.39	.39	1.00

Wagner's UHR Pairwise Comparisons

In Study 1, I reported that the pairwise comparisons between average Wagner's UHR scores for autistic and non-autistic expressions were all statistically significant. Table A4 shows the relevant statistics.

Table A4.

Study 1 Average Wagner's UHR for Autistic and Non-Autistic Posers by Emotion (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(4045)	Effect Size
Anger	.27 (.12)	.21 (.11)	7.12***	0.52
Disgust	.38 (.15)	.27 (.11)	14.50***	1.07
Fear	.12 (.10)	.10 (.09)	2.50*	0.19
Happiness	.83 (.14)	.72 (.14)	15.19***	1.12
Sadness	.36 (.12)	.24 (.10)	15.91***	1.17
Surprise	.34 (.10)	.24 (.10)	13.93***	1.02

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. *p <.05; ***p < .001.

Appendix B- Study 2

Emotion Recognition Accuracy Pairwise Comparisons

Table B1 shows the pairwise comparisons for emotion recognition accuracy between autistic and non-autistic posers. Means and standard deviations presented are averaged across the two levels of timing condition.

Table B1.

Average Recognition Accuracy for Autistic and Non-Autistic Posers by Emotion in Study 2, Averaged Over Timing Condition (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	$t(1727)$	Effect Size
Anger	.51 (.18)	.43 (.16)	5.00***	0.56
Disgust	.64 (.14)	.59 (.13)	3.03**	0.34
Fear	.29 (.15)	.22 (.14)	4.57***	0.51
Happiness	.88 (.10)	.88 (.08)	-0.06	0.01
Sadness	.58 (.14)	.56 (.16)	1.54	0.17
Surprise	.61 (.15)	.48 (.14)	8.40***	0.94

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. **$p < .01$;***$p < .001$.

Poser Rank Correlation Matrix

Table B2 shows the correlation matrices for poser rank across emotion in the timing conditions.

Table B2.

Study 2 Correlation Matrices for Poser Rank in Emotion Recognition Accuracy in Each of the Timing Conditions.

Condition		Anger	Disgust	Fear	Happiness	Sadness	Surprise
Timed							
	Anger	1.00					
	Disgust	.08	1.00				
	Fear	.15	.27	1.00			
	Happiness	.18	.23	.10	1.00		
	Sadness	.14	-.18	.24	.18	1.00	
	Surprise	.39	.32	.42	.44	.30	1.00
Untimed		Anger	Disgust	Fear	Happiness	Sadness	Surprise
	Anger	1.00					
	Disgust	.08	1.00				
	Fear	.29	.27	1.00			
	Happiness	.14	.13	.20	1.00		
	Sadness	.27	-.12	.20	.08	1.00	
	Surprise	.41	.36	.35	.31	.29	1.00

Wagner's UHR Pairwise Comparisons

In Study 2, I reported that the pairwise comparisons between average Wagner's UHR scores for autistic and non-autistic expressions were statistically significant. Table B3 shows the pairwise comparisons between autistic and non-autistic expressions in the two timing conditions, averaged over emotions. Table B4 shows the pairwise comparisons between autistic and non-autistic expressions in the six emotions, averaged over timing condition.

Table B3.

Study 2 Average Wagner's UHR Score for Autistic and Non-Autistic Expressions in the Timed and Untimed Conditions (SD in Parentheses)

Timing Condition	Autistic Poser	Non-Autistic Poser	$t(1723)$	Effect Size
Timed	.36 (.24)	.30 (.22)	8.68***	0.56
Untimed	.40 (.24)	.32 (.22)	13.58***	0.88

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. ***$p < .001$.

Table B4.

Study 2 Average Wagner's UHR for Autistic and Non-Autistic Posers by Emotion Averaged Across the Timed and Untimed Conditions (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(1723)	Effect Size
Anger	.26 (.12)	.23 (.10)	3.32***	0.37
Disgust	.37 (.13)	.29 (.10)	6.87***	0.77
Fear	.14 (.09)	.12 (.09)	2.22*	0.25
Happiness	.83 (.10)	.74 (.10)	7.76***	0.87
Sadness	.35 (.11)	.26 (.10)	8.19***	0.92
Surprise	.33 (.11)	.22 (.09)	10.26***	1.15

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. *p <.05; ***p < .001.

Appendix C

Multicollinearity with 4 rating dimensions

In addition to running analyses with the awkwardness/posedness ratings and the goodness/intensity ratings averaged into two composite scores, I also conducted analyses with all four ratings unaveraged. Below the results from the linear model predicting recognition accuracy with the four ratings and the emotion depicted. The coefficients for this model can be found in Table C1, but generally the model estimated positive relationships between recognition accuracy and awkwardness, posedness, and goodness, but a negative relationship for intensity. This is troubling as recognition accuracy and intensity have a positive correlation, $r = .59$. Furthermore, when intensity is included in a model when goodness is excluded, the estimated coefficient for intensity then becomes positive, $\beta = 0.16$. These both suggest that the model may be improperly estimating coefficients because the independent variables are collinear.

Table C1.

Estimated Coefficients from Linear Model Predicting Recognition Accuracy with Four Rating Variables

	β	t(133)	p
Intercept	-1.02	-7.30	< .001
Emotion- Disgust	0.02	0.49	.626
Emotion- Fear	-0.18	-4.45	< .001
Emotion-Happiness	0.26	5.73	< .001
Emotion-Sadness	0.12	2.86	.005
Emotion-Surprise	0.08	2.11	.037
Neurotype- Non-Autistic	0.01	0.30	.763
Awkwardness	0.11	2.53	.013
Posedness	0.17	4.00	< .001
Goodness	0.58	9.43	< .001
Intensity	-0.34	-5.94	< .001

Note. The intercept term in this model represents the estimate for autistic expressions of anger, the reference levels for the categorical variables of poser neurotype and emotion. Coefficients for the effect of poser neurotype should be interpreted as the difference between autistic and non-autistic expressions. Coefficients for the levels of emotion should be interpreted as the difference in recognition accuracy for that emotion to the reference level.

To investigate whether there were problematic levels of multicollinearity, I calculated the variance inflation factor (VIF) for the independent predictors described in the model above. For emotion, poser neurotype, awkwardness, and posedness, the variance inflation scores were acceptable (all less than 5: Emotion = 1.80, Poser Neurotype = 1.15, Awkwardness = 4.95, Posedness = 4.69; see Chatterjee, 2012; Midi & Bagheri, 2010). However, both goodness and intensity had VIF scores greater than traditional cutoffs for acceptable multicollinearity (i.e., ≥ 10, Goodness = 19.15, Intensity = 18.69). Thus, there is evidence to suggest that models including these un-averaged ratings do not properly estimate their relationship with the dependent variable. As a result, I calculated the composite scores reported in Study 3.

Importance Analyses using Study 2's Recognition Accuracy Data

In Study 3, I reported that in addition to the importance analyses based on Study 1's emotion recognition accuracy data, I conducted the same set of analyses with Study 2's untimed emotion recognition accuracy data, which showed a comparable set of results. I present those below.

With the data from the untimed condition reported in Study 2, I calculated the proportion of times an expression was correctly recognized—comparable to an emotion recognition accuracy score. This became the dependent variable in a model that also included poser neurotype, emotion depicted, and each expression's average awkwardness/posedness and goodness/intensity composites. The omnibus test on this model revealed a statistically significant result $F(8, 135) = 39.02$, $p < .001$, $R^2_{adjusted} = .68$, see Table C2 for full information about coefficients. As can be seen in the table, as with Study 1's data, average goodness/intensity is a significant predictor, while poser neurotype and average awkwardness/posedness score are not.

Table C2.

Estimated Coefficients from Linear Model Predicting Recognition Accuracy

	β	*t*(135)	*p*
Intercept	-0.32	-2.77	.006
Emotion- Disgust	0.01	0.13	.893
Emotion- Fear	-0.18	-3.45	< .001
Emotion-Happiness	0.35	6.39	< .001
Emotion-Sadness	0.17	3.29	.001
Emotion-Surprise	0.07	1.35	.181
Neurotype- Non-Autistic	0.03	0.79	.433
Awkwardness/Posedness	0.03	1.16	.247
Goodness/Intensity	0.24	11.77	< .001

Note. The intercept term in this model represents the estimate for autistic expressions of anger, the reference levels for the categorical variables of poser neurotype and emotion. Coefficients for the effect of poser neurotype should be interpreted as the difference between autistic and non-autistic expressions. Coefficients for the levels of emotion should be interpreted as the difference in recognition accuracy for that emotion to the reference level.

Next, I conducted an importance analysis with the "relaimpo" package in R (Grömping, 2006) to determine which of these variables contributed the most to recognition accuracy. As with Study 1's data, average goodness/intensity score and emotion together contributed the most, and did not differ from each other. Both, however, each contributed significantly more than either poser neurotype or mean awkwardness/posedness score, the two of which did not differ from one another, see Table C3 for full estimates and confidence intervals. Based on these results, it is clear that whether the importance analyses are conducted on data from Study 2's untimed condition or Study 1's data, the conclusions drawn are the same. Therefore, as Study 1 has many more participants than Study 2's untimed condition, those data are reported in Study 3.

Table C3.

Estimated Contribution to Total Variance in Emotion Recognition Accuracy

Model Term	Estimated Contribution [95% Confidence Interval]
Emotion	.31 [.23, .42][A]
Poser Neurotype	.01 [.00, .03][B]
Awkwardness/Posedness	.00 [.00, .02][B]
Goodness/Intensity	.38 [.28, .47][A]

Note. Superscripts denote which model terms contribute significantly different amounts of variance to emotion recognition accuracy. Terms with different superscripts contribute significantly different amounts of information. Statistical significance is determined by examining whether the bootstrapped 95% confidence intervals of the estimate overlap.

Fit Statistics for Linear vs. Mixed Effects Model Predicting Recognition Accuracy

In Study 3, I reported that when predicting recognition accuracy by poser neurotype, emotion, goodness/intensity score, and awkwardness/posedness score, I fit both linear and mixed effects models. I report the results from the linear model because it is both more parsimonious and has better fit statistics than the mixed effects model. The statistics that led me to this conclusion are reported in Table C4.

Table C4.

Fit Statistics Comparing the Linear and Mixed Effects Models Predicting Recognition Accuracy in Study 2

Model	Chi-Square Test	AIC	BIC	R^2
Linear	-	-94.40	-64.70	.73
Mixed Effects	$\Delta\chi^2(1) = 0, p = 1$	-45.86	-13.20	.72

As Table C4 shows, the Chi-square difference in log likelihood test did not yield a statistically significant result and the model R^2 also suggests that neither model has an advantage in explaining variance in recognition accuracy. Both of these suggest that the more parsimonious model (i.e., the linear model) is appropriate. Furthermore, when comparing one or more models, the lower the AIC and BIC scores the better. As the linear model has lower scores for both metrics, it is the more appropriate model.

Importance Analysis Confidence Intervals

In Study 3 I also reported the relative contribution to the R^2 for each independent predictor from the linear model reported above. The confidence intervals for each estimate and which estimates significantly differ are reported in Table C5.

Table C5

Relative Contribution to Variance in Recognition Accuracy Explained by each Independent Variable

Model Term	Estimated Contribution [95% Confidence Interval]
Emotion	.34 [.26, .46]^{A}
Poser Neurotype	.01 [.00, .03]^{B}
Awkwardness/Posedness Score	.00 [.00, .02]^{B}
Goodness/Intensity Score	.38 [.27, .47]^{A}

Note. Superscripts denote which model terms contribute significantly different amounts of variance to emotion recognition accuracy. Terms with different superscripts contribute significantly different amounts of information. Statistical significance is determined by examining whether the bootstrapped 95% confidence intervals of the estimate overlap.

Appendix D- Study 5

Importance Analysis Linear vs. Mixed Effects Model Comparison

In Study 5 I reported that for the importance analysis which investigated each predictor's contribution to the variance in emotion recognition accuracy, I used a linear model to conduct this analysis. I also fit those data for a mixed effects model, and compared these two models to determine which was more appropriate. Model fit statistics are reported in Table D1. Though the chi-square test between the two models suggested the more complex (i.e., the mixed effects) model was more appropriate, the AIC and BIC values suggested the linear model was more appropriate. Because of this, and because the "relaimpo" package is not optimized for mixed effects models, I used the simple linear model.

Table D1

Model Fit Statistics for Linear and Mixed Effects Model

Model	Chi-Square Test	AIC	BIC	R^2
Linear	-	-231.16	-194.77	.75
Mixed Effects	$\Delta\chi^2(1) = 7.34$, $p = .007$	-183.82	-143.80	.75

Wagner's UHR Pairwise Comparisons

In Study 5 I referenced the pairwise comparisons between the autistic and non-autistic posers within each emotion category, for expressions from the standard and communicate conditions. The full pairwise comparisons can be found in Table D3 below.

Table D3.

Pairwise Comparisons for Wagner's UHR Scores Between Autistic and Non-Autistic Posers, Broken Down by Each Stimuli Condition and Emotion

Stimuli Condition	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	*t*(3751)	Effect Size
Standard					
	Anger	.28 (.12)	.23 (.11)	4.55***	0.49
	Disgust	.39 (.13)	.30 (.11)	8.70***	0.93
	Fear	.15 (.09)	.11 (.09)	3.33***	0.36
	Happiness	.85 (.11)	.74 (.11)	9.78***	1.04
	Sadness	.37 (.11)	.25 (.09)	10.71***	1.14
	Surprise	.33 (.10)	.22 (.10)	9.10***	0.97
Communicate					
	Anger	.39 (.14)	.33 (.11)	5.67***	0.62
	Disgust	.55 (.15)	.39 (.12)	14.11***	1.54
	Fear	.19 (.13)	.16 (09)	2.65**	0.29
	Happiness	.77 (.12)	.65 (.11)	10.73***	1.17
	Sadness	.45 (.13)	.30 (.09)	13.61***	1.49
	Surprise	.41 (.12)	.34 (.12)	5.81***	0.63

Note. Effect size reported is from the "eff_size" function in the "emmeans" package (Lenth, 2022). It should be interpreted equivalently to Cohen's D. ***p* <.01; ****p* < .001.

Importance Analysis Estimates and Comparisons

In Study 5 I reported the relative contribution to the R^2 for each independent predictor of recognition accuracy in the importance analysis. The confidence intervals for each estimate and which estimates significantly differ are reported in Table D4.

Table D4

Relative Contribution to Variance in Recognition Accuracy Explained by Each Independent Variable

Model Term	Estimated Contribution [95% Confidence Interval]
Emotion	.26 [.21, .33]^{A}
Poser Neurotype	.01 [.00, .03]^{B}
Goodness/Intensity Score	.48 [.41, .55]^{C}
Condition	.01 [.00, .03]^{B}

Note. Superscripts denote which model terms contribute significantly different amounts of variance to emotion recognition accuracy. Terms with different superscripts contribute significantly different amounts of information. Statistical significance is determined by examining whether the bootstrapped 95% confidence intervals of the estimate overlap.

Appendix E- Gender Analyses

Below, I report the results of the analyses investigating whether there was a gender effect because of the inclusion of 3 female autistic posers. One concern was that by including three female faces in the set of autistic posers, this might artificially inflate the emotion recognition accuracy for the autistic faces. As there were only 3 female autistic posers, and no female non-autistic posers, I could not conduct analyses with poser-gender as a covariate. Instead, to investigate any effects of poser gender, I conducted the analyses identically to how they are reported in the main body of the dissertation, removing the responses to the three female autistic posers.

To foreshadow the results of these analyses, I did not find evidence of any gender-based effect. Instead, removing the female autistic posers led to a reduction in recognition accuracy and goodness/intensity ratings for autistic expressions of some emotions (particularly disgust and fear) and strengthened autistic expressions' advantages for other emotions (such as anger and surprise). If there was a general reduction in recognition accuracy and goodness/intensity ratings, this would suggest that including the findings reported in this dissertation may be driven by effects gender, rather than by posers' neurotype. However, this was not the pattern of results observed when I removed the three autistic female posers, and thus I conclude there are not gender-based effects driving my larger conclusions. Below are the summaries of the analyses I conducted, all of which do not include responses to the three autistic female posers.

Study 1

Emotion Recognition Accuracy

As in Study 1, I conducted a 2 (poser neurotype: autistic and non-autistic) x 6 (emotion: anger, disgust, fear, happiness, sadness, surprise) ANOVA using linear mixed effects models. To account for multiple observations, a random intercept term for each participant was included. The results of this analysis revealed significant main effects of poser neurotype, $F(1, 4070) = 331.14$, $p < .001$, and emotion, $F(5, 4070) = 1667.15$, $p < .001$. There was also a significant two-way interaction between poser neurotype and emotion, $F(5, 4070) = 44.91$, $p < .001$. To follow-up on the two-way interaction, I calculated the pairwise comparisons between autistic and non-autistic expressions for each of the six emotions. The full inferential statistics are reported in Table E1. As the table shows, and as was the case with Study 1, when there is a difference between autistic and non-autistic expressions, it is always in favor of the autistic expressions. But, unlike Study 1 where the only non-significant difference was for happiness, here there were not significant differences between autistic and non-autistic expressions of disgust and fear.

Table E1.

Average Emotion Recognition Accuracy for Male Autistic and Non-Autistic Posers by Emotion (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(4070)	Effect Size
Anger	.57 (.21)	.41 (.16)	14.28***	1.05
Disgust	.57 (.19)	.56 (.15)	0.91	0.07
Fear	.19 (.17)	.18 (.14)	$1.70^{\dagger}$	0.13
Happiness	.92 (.14)	.89 (.11)	2.72**	0.20
Sadness	.61 (.15)	.52 (.17)	8.65***	0.64
Surprise	.68 (.17)	.50 (.16)	16.30***	1.20

Note. Effect size was calculated using “emmeans” package in R (Lenth, 2022), it should be interpreted equivalently to Cohen’s D. $^{\dagger}p < .10$; $*p < .05$; $**p < .01$; $***p < .001$.

Wagner's UHR

I conducted complementary analyses using Wagner's UHR as the dependent variable, to account for any bias introduced by participants' tendency to use one response option more than others. Here I also conducted a 2 x 6 ANOVA with random intercepts for each participant. The results of this analysis revealed significant main effects of poser neurotype, $F(1, 4027) = 958.35$, $p < .001$, and emotion, $F(5, 4027.2) = 3331.26$, $p < .001$, as well as by a significant two-way interaction between poser neurotype and emotion, $F(5, 4026.9) = 45.27$, $p < .001$. To follow up on this interaction, I again compared hit rates for autistic and non-autistic expressions within each emotion category, which are reported in Table E2. Hit rates were higher for autistic expressions in all emotions but fear, where they did not differ from non-autistic expressions.

Table E2.

Average Wagner's UHR for Male Autistic and Non-Autistic Posers by Emotion (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(4025)	Effect Size
Anger	.32 (.15)	.21 (.11)	13.17***	0.97
Disgust	.35 (.16)	.27 (.11)	9.53***	0.70
Fear	.11 (.10)	.10 (.09)	0.88	0.07
Happiness	.88 (.15)	.72 (.14)	20.21***	1.48
Sadness	.38 (.13)	.24 (.10)	17.81***	1.31
Surprise	.35 (.12)	.24 (.10)	14.63***	1.07

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. ***$p < .001$.

Study 1 Summary

Using the responses to male and female posers, Study 1 found that autistic expressions were recognized with greater accuracy for all emotions except for happiness, where they did not differ from non-autistic expressions. Likewise, when bias in participants' responses was accounted for (using Wagner's UHR as the dependent variable), autistic expressions were recognized more accurately for all emotions. Removing the responses to the female posers, all of whom were autistic, I found slightly different patterns for both emotion recognition and Wagner's UHR: differences in recognition accuracy between autistic and non-autistic posers were reduced for disgust and fear but increased for expressions of anger and surprise. Since the effect was not uniformly in the same direction across all emotions, and given that there are still significant differences between the autistic and non-autistic expressions, I cannot conclude that there is an effect of poser gender.

Study 2

Emotion Recognition

In Study 2, I added the manipulation where participants saw the stimuli used in Study 1 for either an unlimited amount of time, or for 800 ms. Here, I investigated participants' responses using a 2 (poser neurotype) x 6 (emotion category) x 2 (condition: timed or untimed) ANOVA, with random intercepts for each participant, and level of autism symptomatology as a covariate. Crucially, with the full set of responses, Study 2 did not find a significant three-way interaction. The analyses including responses to only the male stimuli found a similar pattern: the main effects of poser neurotype, $F(1, 1727) = 92.62$, $p < .001$, emotion, $F(5, 1727) = 654.\ 60$, $p < .001$, and condition, $F(1, 156) = 13.16$, $p < .001$, were all significant. Also like in Study 2, the two-way interactions between poser neurotype and emotion, $F(5, 1727) = 23.44$, $p < .001$, poser neurotype and condition, $F(1, 1727) = 4.26$, $p = .039$, and emotion and condition, $F(5, 1727) = 2.87$, $p = .014$, were all statistically significant. Finally, also like in Study 2, the three-way interaction between poser neurotype, emotion, and condition was not significant, $F(5, 1727) = 0.31$, $p = .912$, and neither was the effect of the covariate, $F(1, 156) = 1.71$, $p = .193$.

To investigate whether autistic expressions were recognized more accurately than non-autistic expressions, I compared the mean recognition accuracy for autistic and non-autistic expressions in each condition averaged over emotion. Autistic expressions were recognized more accurately than non-autistic expressions in both the timed, $t(1727) = 5.36$, $p < .001$, $d = 0.35$,

($M_{Autistic}$ = .57, *SD* = .24; $M_{Non\text{-}Autistic}$ = .52, *SD* = .23), and in the untimed conditions *t*(1727) = 8.24, *p* < .001, *d* = 0.54 ($M_{Autistic}$ = .61, *SD* = .25; $M_{Non\text{-}Autistic}$ = .53, *SD* = .25).

I also compared recognition accuracy for autistic and non-autistic expressions in each emotion, averaged over condition (see Table E3). Autistic expressions were recognized with greater accuracy than non-autistic expressions for anger, happiness, sadness, and surprise. For fear, autistic and non-autistic expressions did not significantly differ from one another, and for disgust, non-autistic expressions were recognized significantly better, though with a small effect. This pattern, though, is consistent with that in Study 1, where removing the female posers reduced pairwise differences in disgust and fear, but accentuated them in anger and surprise, which is not consistent with a gender effect.

Table E3.

Average Emotion Recognition Accuracy for Male Autistic and Non-Autistic Posers by Emotion, Averaged Over Timing Condition (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(1727)	Effect Size
Anger	.59 (.20)	.43 (.16)	9.70***	1.09
Disgust	.56 (.17)	.59 (.13)	-1.98*	-0.22
Fear	.25 (.15)	.22 (.14)	1.70†	0.19
Happiness	.91 (.11)	.88 (.08)	2.07*	0.23
Sadness	.59 (.14)	.56 (.16)	2.07*	0.23
Surprise	.65 (.16)	.48 (.14)	10.02***	1.12

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. †$p < .10$; *$p <.05$; ***$p < .001$. The pairwise comparisons between autistic and non-autistic posers for expressions of happiness and sadness were of the same magnitude, and thus revealed identical t-statistics and effect sizes.

Wagner's UHR

I also conducted the same analysis above, but with Wagner's UHR as the dependent variable. Using responses to male and female posers, Study 2 also did not find a significant three-way interaction between poser neurotype, emotion, and condition. Using only responses to the male stimuli, I found significant main effects of poser neurotype, $F(1, 1722.44) = 296.06$, $p < .001$, emotion, $F(5, 1722.41) = 1564.10$, $p < .001$, and condition, $F(1, 156.01) = 13.97$, $p < .001$. These were all superseded by the two-way interactions between poser neurotype and emotion, $F(5, 1722.43) = 16.38$, $p < .001$, and poser neurotype and condition, $F(1, 1722.44) = 9.51$, $p <$

.001. The two-way interaction between emotion and condition, $F(5, 1722.42) = 2.16$, $p = .056$, the three-way interaction between poser neurotype, emotion, and condition, $F(5, 1722.43) = 0.29$, $p = .919$, and the effect of the covariate, $F(1, 156.03) = 1.87$, $p = .174$, were all not significant.

To investigate whether autistic expressions were recognized more or less accurately after accounting for participants' tendency to use one response option, I investigated pairwise comparisons by neurotype within each timing condition. As before, autistic expressions were recognized more accurately than non-autistic expressions in both the timed, $t(1727) = 10.02$, $p < .001$, $d = 0.65$, ($M_{Autistic} = .37$, $SD = .26$; $M_{Non\text{-}Autistic} = .30$, $SD = .22$), and in the untimed conditions $t(1727) = 14.30$, $p < .001$, $d = 0.93$ ($M_{Autistic} = .41$, $SD = .26$; $M_{Non\text{-}Autistic} = .32$, $SD = .22$).

I next investigated whether autistic expressions were recognized more or less accurately than non-autistic expressions in each emotion, averaged over timing condition (see Table E4). Here, whenever there was a significant difference between the two poser groups, it was always in favor of autistic expressions. Autistic expressions of anger, disgust, happiness, sadness, and surprise were recognized more accurately than non-autistic expressions. There was no difference in Wagner's UHR for fear. Thus, after accounting for participant's response biases, a similar pattern to that reported in Study 2 was observed for responses to just the male stimuli.

Table E4.

Average Wagner's UHR for Male Autistic and Non-Autistic Posers by Emotion, Averaged Over Timing Condition (SD in Parentheses)

Emotion	Autistic Poser	Non-Autistic Poser	*t*(1722)	Effect Size
Anger	.32 (.14)	.23 (.10)	7.63***	0.86
Disgust	.33 (.15)	.29 (.10	3.22***	0.36
Fear	.13 (.10)	.12 (.09)	0.97	0.11
Happiness	.87 (.12)	.74 (.10)	11.22***	1.26
Sadness	.37 (.11)	.26 (.10)	9.09***	1.02
Surprise	.34 (.12)	.22 (.09)	10.07***	1.13

Note. Effect size was calculated using "emmeans" package in R (Lenth, 2022), it should be interpreted equivalently to Cohen's D. ***p < .001.

Study 2 Summary

A similar pattern to Study 1 was found here. Again, once the female autistic posers were removed, recognition for autistic expressions of disgust and fear decreased, but increased for anger and surprise. Overall, though, autistic expressions were recognized more accurately than non-autistic expressions, especially once accounting for participants' tendencies to use one response option more than others. This pattern of results provides no evidence for a poser-gender effect in these data.

Study 3

Rating Dimensions Analyses

In Study 3, I investigated whether autistic and non-autistic expressions were perceived as more or less awkward/posed and good/intense for each of the six emotions. Here, I report the same analyses, including only the response to the male stimuli. As will be shown below, the overall pattern of results remains unchanged, again suggesting that there is no effect of poser-gender on these results.

To the male stimuli, I fit a 2 (poser neurotype: autistic or non-autistic) x 6 (emotion: anger, disgust, fear, happiness, sadness, or surprise) x 2 (rating dimension: awkwardness/posedness or goodness/intensity) ANOVA, with random intercepts for each poser identity, and for each participant. The results of this analysis revealed a marginal main effect of poser neurotype, $F(1, 19) = 4.17$, $p = .055$, and significant main effects of emotion, $F(5, 20734) = 100.33$, $p < .001$, and rating dimension, $F(1, 20728) = 151.16$, $p < .001$. The two-way interactions between poser neurotype and emotion, $F(5, 20733) = 17.35$, $p < .001$, poser neurotype and rating dimension, $F(1, 20728) = 17.17$, $p < .001$, and emotion and rating dimension, $F(5, 20728) = 104.58$, $p < .001$, were all significant. But, all of these effects were superseded by the significant three-way interaction between poser neurotype, emotion, and rating dimension, $F(5, 20728) = 26.14$, $p < .001$.

To break down this three-way interaction, I investigated the two-way interaction between poser neurotype and emotion within each rating dimension. The two-way interaction was significant in both the awkwardness/posedness dimension, $F(5, 20728.08) = 28.29$, $p < .001$, and in the goodness/intensity dimension, $F(5, 20728.08) = 15.21$, $p < .001$. Therefore, I investigated the pairwise comparisons between autistic and non-autistic expressions separately for each emotion in each rating dimension (see Table E5). These analyses revealed that autistic expressions were given higher awkwardness/posedness ratings than non-autistic expressions for anger and surprise, and higher goodness/intensity ratings for disgust, fear, and surprise. This pattern of results is the same as that reported in Study 3 (though with the male and female stimuli, autistic expressions of disgust were also given higher awkwardness/posedness ratings), and thus shows no evidence of a poser gender effect.

Table E5.

Pairwise Comparisons for Average Ratings for Autistic and Non-Autistic Expressions, Broken Down by Rating Dimensions and Emotion (SD in Parentheses)

Rating Dimension	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	*t*(22.5)	Effect Size
Awkwardness/Posedness					
	Anger	3.26 (1.15)	2.61 (1.08)	3.81***	0.62
	Disgust	3.10 (1.15)	2.77 (1.09)	1.91†	0.31
	Fear	2.87 (1.10)	2.76 (1.16)	0.67	0.11
	Happiness	2.53 (1.22)	2.59 (1.14)	-0.36	-0.06
	Sadness	3.00 (1.18)	2.49 (1.12)	2.98**	0.48
	Surprise	2.96 (1.06)	2.86 (1.12)	0.58	0.09
Goodness/Intensity					
	Anger	3.13 (1.07)	2.84 (1.14)	1.70	0.28
	Disgust	3.78 (1.15)	3.19 (1.21)	3.45**	0.56
	Fear	2.93 (1.22)	2.36 (1.19)	3.32**	0.54
	Happiness	3.38 (1.20)	3.21 (1.14)	0.98	0.16
	Sadness	2.78 (1.12)	2.58 (1.12)	1.14	0.19
	Surprise	3.19 (1.16)	2.62 (1.25)	3.30**	0.53

Note. Effect size reported is from the “eff_size” function in the “emmeans” package (Lenth, 2022). It should be interpreted equivalently to Cohen’s D. †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Study 4

Rating Dimensions Analyses

In Study 4, I investigated whether goodness/intensity ratings for the autistic and non-autistic expressions would differ if those expressions came from either Brewer et al.'s (2016) standard or communicate conditions. With the full set of responses, I found that autistic expressions in the standard condition were given higher goodness/intensity ratings for disgust, fear, and surprise, but there were no differences for stimuli from the communicate condition. I found a similar pattern when I conducted identical analyses with just the responses to the male stimuli. I conducted a 2 (poser neurotype) x 6 (emotion) x 2 (stimulus condition: standard or communicate) ANOVA, with random intercepts for each poser identity, and for each participant. In this analysis, the main effects of poser neurotype, $F(1, 19) = 1.82$, $p = .194$, and stimulus condition, $F(1, 147.3) = 0.16$, $p = .689$, were not significant, but the main effect of emotion, $F(5, 17940.9) = 421.41$, $p < .001$, was. There was a marginal two-way interaction between poser neurotype and stimulus condition, $F(1, 17947.6) = 2.91$, $p = .088$, and significant two-way interactions between poser neurotype and emotion, $F(5, 17940.9) = 19.45$, $p < .001$, and stimulus condition and emotion, $F(5, 17940.9) = 41.63$, $p < .001$. These were all superseded, though, by a significant three-way interaction between poser neurotype, emotion, and stimulus condition, $F(5, 17940.9) = 13.40$, $p < .001$.

To break down this interaction, I investigated the two-way interaction between poser neurotype and emotion within each stimulus condition. These effects were significant in both the standard, $F(5, 17940.82) = 16.79$, $p < .001$, and in the communicate conditions, $F(5, 17941.28) = 15.88$, $p < .001$. Thus, I compared the pairwise comparisons between autistic and non-autistic faces for each emotion, in each stimulus condition (see Table E6).

Table E6.

Pairwise Comparisons for Average Goodness/Intensity Ratings for Autistic and Non-Autistic Expressions, Broken Down by Rating Dimensions and Emotion (SD in Parentheses)

Stimulus Condition	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	$t(20.4)$	Effect Size
Standard					
	Anger	3.23 (1.20)	3.01 (1.13)	0.81	0.22
	Disgust	3.91 (1.20)	3.32 (1.27)	2.10*	0.56
	Fear	2.92 (1.26)	2.35 (1.24)	2.08†	0.56
	Happiness	3.72 (1.22)	3.60 (1.17)	0.41	0.11
	Sadness	2.77 (1.21)	2.50 (1.15)	0.97	0.26
	Surprise	3.46 (1.26)	2.85 (1.39)	2.18*	0.58
Communicate					
	Anger	3.67 (1.05)	2.99 (1.21)	2.41*	0.65
	Disgust	3.82 (1.02)	3.53 (1.18)	1.04	0.28
	Fear	3.15 (1.19)	2.62 (1.42)	1.88†	0.51
	Happiness	3.31 (1.31)	3.13 (1.35)	0.66	0.18
	Sadness	2.62 (1.16)	2.57 (1.20)	0.23	0.06
	Surprise	3.42 (0.94)	3.10 (1.28)	1.14	0.31

Note. Effect size reported is from the "eff_size" function in the "emmeans" package (Lenth, 2022). It should be interpreted equivalently to Cohen's D. †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Overall, patterns were similar to those reported in the body of the dissertation. In the standard condition, autistic expressions of disgust, fear, and surprise were rated as better/more intense (though note that for fear, the effect just failed to reach statistical significance, $p = .051$). In the communicate condition, there were no significant differences for autistic and non-autistic expressions for any of these emotions. Interestingly, in the communicate condition, autistic expressions of anger were rated as better/more intense than non-autistic expressions, a finding I did not observe when analyzing responses to the male and female posers. However, this is consistent with the previous findings that removing the female posers exacerbated differences between autistic and non-autistic expressions of anger. Regardless, however, because this effect is not uniform across the different emotions, this is not evidence of a poser gender effect.

Study 5

Emotion Recognition Analyses

As in Study 5, I conducted analyses with both emotion recognition accuracy and Wagner's UHR as dependent variables. In both of these analyses, I fit the dependent variables to mixed effects models and conducted 2 (poser neurotype) x 6 (emotion) x 2 (stimulus condition) ANCOVAs, with BAP-Q as a covariate. I fit a random intercept for each participant to account for multiple observations.

Emotion Recognition Accuracy. The results of the emotion recognition accuracy analyses revealed the effect of the covariate, $F(1, 341) = 1.92$, $p = .166$, and the two-way interaction between poser neurotype and stimulus condition, $F(1, 3762) = 1.30$, $p = .254$, were not significant. There were significant main effects of poser neurotype, $F(1, 3762) = 344.42$, $p < .001$, emotion, $F(5, 3762) = 1176.11$, $p < .001$, and stimulus condition, $F(1, 341) = 110.21$, $p <$

.001. The two-way interactions between poser neurotype and emotion, $F(5, 3762) = 33.78$, $p <$ .001, and between emotion and stimulus condition, $F(5, 3762) = 38.64$, $p < .001$, were both significant. These were all superseded by the significant three-way interaction between poser neurotype, emotion, and stimulus condition, $F(5, 3762) = 4.76$, $p < .001$.

To break down the three-way interaction, I compared the effects of poser neurotype and emotion at each level of stimulus condition. The two-way interaction between posed neurotype and emotion was significant in both the standard, $F(5, 3762) = 20.74$, $p < .001$, and communicate conditions, $F(5, 3762) = 17.87$, $p < .001$. Therefore, I investigated the pairwise comparisons between autistic and non-autistic expressions for each emotion, within each of the two stimulus conditions.

The full inferential statistics from these comparisons can be found in Table E7, but to summarize: In the standard condition, autistic expressions were recognized more accurately than non-autistic expressions for anger, fear, sadness, and surprise. Autistic and non-autistic expressions of disgust and happiness did not differ from one another. In the communicate condition, autistic expressions were recognized more accurately than non-autistic expressions for all emotions but sadness, where they did not differ from one another.

Table E7.

Pairwise Comparisons of Emotion Recognition Accuracy for Autistic and Non-Autistic Expressions for the Six Emotions in Each Stimulus Condition

Stimulus Condition	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	*t*(3762)	Effect Size
Standard					
	Anger	.58 (.20)	.43 (.16)	9.73***	1.04
	Disgust	.61 (.18)	.60 (.15)	0.38	0.04
	Fear	.25 (.15)	.21 (.13)	3.01**	0.32
	Happiness	.93 (.11)	.90 (.07)	1.49	0.16
	Sadness	.60 (.15)	.53 (.15)	4.35***	0.46
	Surprise	.65 (.17)	.47 (.16)	11.58***	1.23
Communicate					
	Anger	.67 (.20)	.51 (14)	10.14***	1.11
	Disgust	.74 (.16)	.66 (.14)	5.05***	0.55
	Fear	.35 (.20)	.29 (.13)	3.78***	0.41
	Happiness	.87 (.10)	.80 (.11)	3.96***	0.43
	Sadness	.62 (.13)	.63 (.15)	-0.18	-0.02
	Surprise	.76 (.17)	.58 (.16)	10.99***	1.20

Note. Effect size reported is from the “eff_size” function in the “emmeans” package (Lenth, 2022). It should be interpreted equivalently to Cohen’s D. **$p < .01$; ***$p < .001$.

Wagner's UHR. Next, I conducted identical analyses, but with Wagner's UHR as the dependent variable. These analyses revealed a similar pattern of results. The 2 x 6 x 2 ANCOVA revealed that the effect of the covariate was not statistically significant, $F(1, 339.2) = 1.50$, $p = .221$. The main effects of poser neurotype, $F(1, 3747.1) = 1060.43$, $p < .001$, emotion, $F(5, 3747.6) = 2334.33$, $p < .001$, and stimulus condition, $F(1, 339.6) = 115.12$, $p < .001$, were all significant. All of the two-way interactions were also significant: poser neurotype and emotion, $F(5, 3747.1) = 35.93$, $p < .001$, poser neurotype and stimulus condition, $F(1, 3747.1) = 14.47$, $p < .001$, emotion and stimulus condition, $F(5, 3747.6) = 87.91$, $p < .001$. These were all superseded by the significant three-way interaction between poser neurotype, emotion, and stimulus condition, $F(5, 3747.1) = 8.71$, $p < .001$.

In following up on the three-way interaction, the two-way interactions between poser neurotype and emotion were significant in both the standard, $F(5, 3746.92) = 17.34$, $p < .001$, and communicate conditions, $F(5, 3746.61) = 27.09$, $p < .001$. As such, I investigated the pairwise comparisons between autistic and non-autistic expressions for all emotions, in each of the two stimulus conditions. Full inferential statistics can be found in Table E8. Overall, though, autistic expressions had higher hit rates than non-autistic expressions for all emotions in both conditions, except in the standard condition, where there was no difference for fear.

Table E8.

Pairwise Comparisons of Wagner's UHR for Autistic and Non-Autistic Expressions for the Six Emotions in Each Stimulus Condition

Stimulus Condition	Emotion	Autistic Poser Mean (SD)	Non-Autistic Poser Mean (SD)	*t*(3747)	Effect Size
Standard					
	Anger	.33 (.15)	.23 (.11)	8.84***	0.94
	Disgust	.36 (.14)	.30 (.11)	5.61***	0.60
	Fear	.13 (.09)	.11 (.09)	1.54	0.17
	Happiness	.90 (.12)	.74 (.11)	12.96***	1.38
	Sadness	.39 (.12)	.25 (.09)	11.54***	1.23
	Surprise	.34 (.12)	.22 (.10)	9.98***	1.06
Communicate					
	Anger	.48 (.18)	.33 (.11)	12.36***	1.35
	Disgust	.55 (.17)	.39 (.12)	12.86***	1.40
	Fear	.20 (.14)	.16(.09)	2.87**	0.32
	Happiness	.82 (.13)	.65 (.11)	14.14***	1.54
	Sadness	.49 (.13)	.30 (.09)	15.32***	1.68
	Surprise	.40 (.13)	.34 (.12)	4.79***	0.52

Note. Effect size reported is from the "eff_size" function in the "emmeans" package (Lenth, 2022). It should be interpreted equivalently to Cohen's D. ***p* < .01; ****p* < .001.

Thus, the pattern observed in the gender analyses for Studies 1-4 was observed in Study 5 as well. Removing the female autistic posers led to autistic expressions of disgust and fear no longer being recognized more accurately than non-autistic expressions, but differences for other emotions, including anger, were accentuated. Again, this pattern of results does not suggest that the three female autistic posers were driving any effects of neurotype observed in the main body of the dissertation.