# *How sensitive are individuals to key fundamentals of action perception?*

An action perception study that examines key action qualities and the impact of autistic traits to not only better define human ability to read the behaviours of other people but also determine where autistic traits impact action perception.

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## Introduction

Action perception is very important for humans to interact successfully in social spaces. It refers to our abilities to interpret the movements and behaviours of other people. And because actions are the main way in which we, individuals, influence the world, studying human abilities to observe and interpret behaviours gives us critical insights into the minds of other people and how we make sense of each other. An action can be perceived in a multitude of ways, from how the action is executed (e.g. action speed) to what the action goals are (e.g. avoiding/ approaching), to why the action is performed (e.g. to communicate), and are even influenced by underlying actor traits (e.g. actor dominance). All these action characteristics enable us to respond within our complex social environment accurately and appropriately.

Different cognitive/neural processes may underly perception of actions. Here, it is worth mentioning the Mirror Neuron System (MNS), who seems to be involved in action perception and understanding (Rizzolatti et al., 1996). It has been shown that the cells within the MNS respond during the execution of a goal-directed action as well as when just observing other individuals perform a goal-directed action (di Pellegrino et al., 1992). As such, it appears that the MNS maps perceptual information about actions upon the motor circuits involved in the generation of those very actions.

Recently a 4-dimensional model of action space has been proposed by Dr Nick Barraclough's lab (Vinton et al., 2022). Computational modelling showed that there are 4 key action qualities on which we evaluate human actions: friendliness, formidableness (intensity or powerfulness of the action), whether the action is planned, and abduction (movement of limbs or objects towards or away from the actor's body). Actions display more or less predominately these 4 different qualities. For example, an action might appear friendly but not formidable (i.e. waving hello). In the past, it has not been possible to develop methods where we can investigate these discrete processes as up to this point stimuli have often varied along many different action qualities at the same time. Isolating the different action dimensions may give us insights into better understanding the individual cognitive and neural processes underlying action perception.

Previous research has suggested that there is interindividual variability in action perception. For example, various disorders and conditions have been shown to also impact people's perception, including schizophrenia (Voss et al., 2010). One of the most important conditions impacting action perception is Autism. Autistic Spectrum Condition (ASC) is a developmental condition that affects 1 in 68 individuals and can profoundly impact the ability to interpret and communicate social information. It is characterised by abnormal functioning in verbal and nonverbal communication, social interactions, and repetitive and/or restricted patterns of behaviour. However, Autism is a spectrum condition which means that autistic traits are present in, and vary across all humans. And since Autism has a detrimental impact on social interactions, it also has an impact on the perception of actions (e.g. Cole et al., 2018), although how Autistic traits impact perception of the 4 different action qualities remains unknown.

In this study, we therefore set out to achieve 2 principal aims. First, we wanted to see if we could develop action stimuli that varied only along single dimensions of action space. Such stimuli would appear to show only one of the action qualities, but not the other 3. We tested this by creating a discrimination task where participants viewed 4 sets of morphed actions each showing only one of the 4 action qualities. We examined whether participants could only detect the one action quality that was varied.

The second aim was to measure how Autistic traits impacted the ability to discriminate the 4 action qualities. For all participants involved in the action discrimination task, we additionally measured their Autistic traits using the Autistic Quotient (AQ) questionnaire (Baron-Cohen et al., 2001). We examined how Autistic traits impacted the ability of individuals to discriminate actions along each of the 4 dimensions

## Methods

### *Participants*

Participants were all students from the University of York recruited via opportunity sample. All had normal or corrected-to-normal vision. Participants gave informed consent and were paid for their participation with Amazon Vouchers. Experiments were approved by the ethics committee of the Departments of

Psychology, University of York, and were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. In total, we aimed to recruit 96 participants.

*Stimuli*

Action stimuli were selected based upon a 4-dimensional model of action perception (Vinton et al., 2022). We aimed to make 4 action morph continua along the 4 dimensions of the identified action space. To do this, we selected actions that were located on either end of one dimension (i.e. one action high, and one action low on the dimension) whilst they varied very little on the other dimensions. For example, to create the stimuli for the friendliness dimension, we morphed the following 2 actions: laughing, scoring +2.684 on the friendly dimension, and stealing, with a -1.416 on the dimension’s axis. Both of these actions had close-to-zero scores on the other 3 dimensions. The actions chosen for the 4 dimensions were: friendliness, (stealing, laughing), formidableness (tearing up paper into multiple pieces to destroy, pushing an object so that it slightly moves), planned (mopping the floor, trying to warm up), abducting (throwing from side, opening a bottle).

Each action was conveyed by animating (using the Unity game engine, https://unity.com) a grey volumetric avatar where face, colour, texture, clothing, or identity information was not present. The only information available was the posture and motion of the actor. To make the continua along each of the 4 action dimensions, we generated action morphs, between the 2 actions that were located at the extremes of the dimension, in 1% steps. Each morph was a result of the combination between these 2 action extremes, conveying a percentage of each source action ranging from 0% action 1 + 100% action 2 up to 100% action 1 + 0% action 2 (see Figure 1, 2, 3, 4).

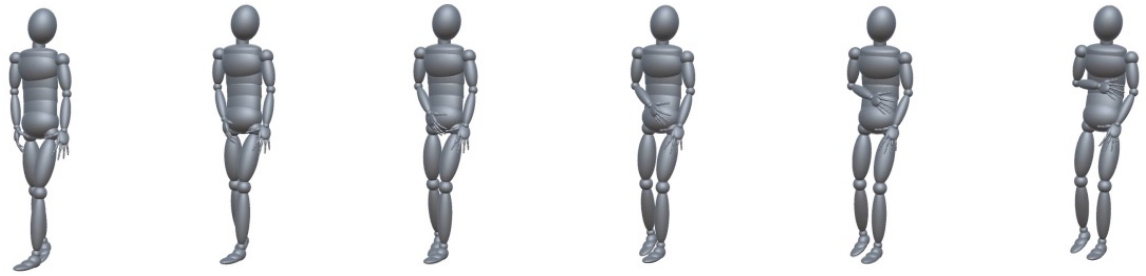

Figure 1. Illustration of frames (0, 20, 40, 60, 80, 100) from the Stealing and Laughing action morph (Friendliness);

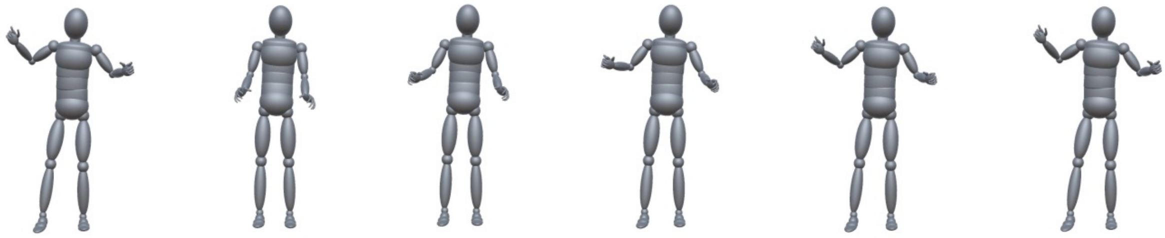

Figure 2. Illustration of frames (0, 20, 40, 60, 80, 100) from the Pushing an object gently and Tearing up paper action morph (Formidableness);

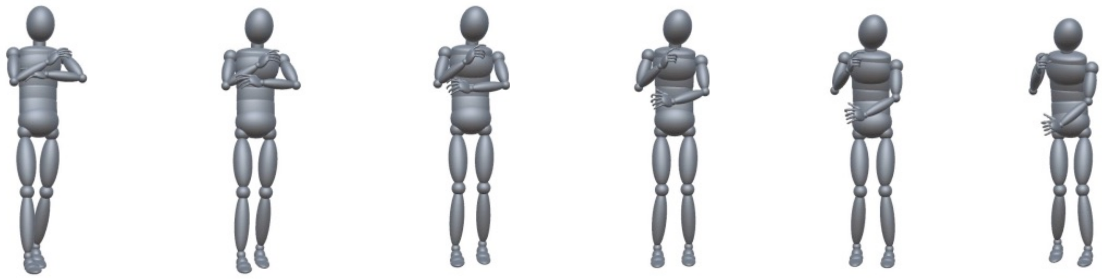

Figure 3. Illustration of frames (0, 20, 40, 60, 80, 100) from the Shivering and Mopping the floor action morph (Planned);

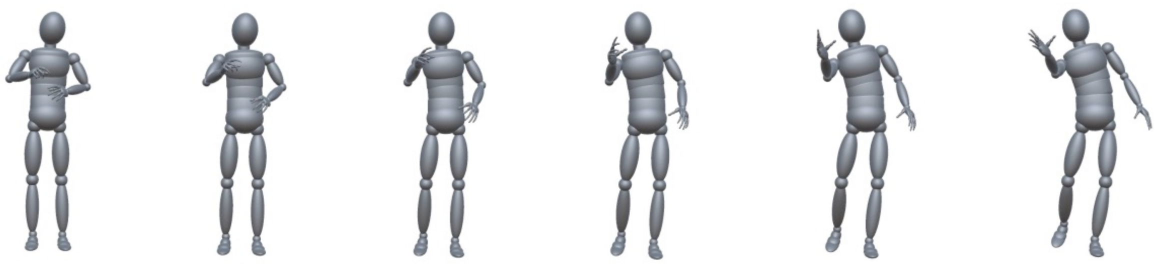

Figure 4. Illustration of frames (0, 20, 40, 60, 80, 100) from the Opening a bottle and Throwing action morph (Abducting).

In order to generate the stimuli that were to be used during the experiment, we played back on-screen using Unity all the morphs in 1% steps between 0% and 100% on each of the 4 continua (101 morphs x 4 continua; 404 actions in total). The playback was recorded at 1280x1080 pixel resolution and 60 frames per second (fps) using OBS Studio and saved as .mp4 files. Action movies were then edited with

Sony Vegas Pro 19 to generate action movies of identical duration for each continuum, and to ensure that no more than 1-2 apparent frames were dropped more than 1-2 frames were dropped during the morphing and playback process. The final versions of each morphed action were then rendered as separate .mp4 files.

*Experimental procedure*

A PC running MATLAB 2021 and the Psychophysics Toolbox was used to control the experiment, present the stimuli, and record participant responses. Participants sat in a dimly lit room approximately .6 m away from a 27-in. TFT monitor (ASUS VP28U, 3840 × 2160 pixels, 60-Hz refresh rate) on which all action stimuli were presented. No demographic information was collected. Participants were carefully assigned to one of the four conditions that determined which action quality was to be judged: friendliness (3); planned (3); formidableness (3); abduction (3). They were then presented with the 4 types of action morphs within separate blocks. To avoid order and position effects, actions and tasks were counterbalanced across blocks and participants respectively. The experiment consisted of brief blocks of testing where actions that varied along one continua and participants had to discriminate them. This task involved the comparison of 2 sequentially presented actions, where one was the standard (an action morph consisting of 50% action 1 and 50% action 2), and a second 'comparison' action. The degree to which the comparison action morph conveyed either action 1 or action 2 was determined by 4 interleaved staircases.

On each trial, participants first viewed a white screen displaying the quality on which the participant had to judge the actions (e.g. "Which action is more friendly"), followed by a 250-ms interval during which a black fixation cross appeared in the centre of the screen. Following the interval, the standard and comparison actions were presented 160-ms apart, the order of which was randomised. Participants had to indicate with a key press which of the two actions, first (key 1) or second (key 2), conveyed the most of the action quality. On every trial, participants had to indicate a response, and would only progress to the next trial once a response was registered. Once a response was registered, there was a 500 ms interval before next trial. Whist the standard remained the same, the comparison action was determined using adaptative staircase rules. There were 4 interleaved staircases with the following reversal rules: 1 up 2 down, 2 up 1 down, 1 up 3 down, 3 up 1 down. Staircase step sizes were 8% and were halved on each of the first 3 reversals. All staircases quit after 10 reversals, and the maximum number of trials per staircase type was 20. Perceptual thresholds from the staircase endpoints were not determined, instead these procedures were used to distribute trials at informative points along the psychometric function (Levitt, 1971), which was fitted using the data from all trials.

Strong order effects can result from perceptual learning and its significant impact on performance (Poggio et al., 1992). To mitigate these effects, each participant performed the discrimination task for a particular combination of action morph and task until their performance plateaued and no improvement in their ability to discriminate the morphs was showed. We determined this by fitting a psychometric function to the data obtained from each block, and once the just noticeable difference (JND) calculated from data in block n was less than 1.5 standard deviation from the JND calculated from data in block n – 1, then these practice sessions were stopped, and the participant moved on to the subsequent block with a different set of action morphs.

*Testing levels of Autistic traits*

At the end of the study, participants had to complete an online AQ questionnaire that measured their degree of autistic traits (reference). This consisted of 50 questions about likes (e.g. ‘it does not upset me if my daily routine is disturbed’). Each question answer was scored to produce a total between 0-50, where a higher score indicated higher degrees of autistic traits. This test alone does not diagnose the presence of Autism since it is self-report test. However, it allowed us to compare AQ score with action quality sensitivity.

*Analysis*

For each participant and set of action morphs, JNDs were computed by first fitting cumulative Gaussian psychometric functions to the data using a maximum likelihood method of fit in MATLAB, while allowing the central tendency (mu) and the standard deviation (sigma) to freely vary. We divided the resulting standard deviations by $\sqrt{2}$ to give an estimate of the standard deviation on a single interval (because we used a 2-IFC procedure; Green & Swets, 1974). The resulting values are JNDs because they indicate the percentage change in the action morph that can be discriminated at the ~76 % level. The JNDs provide a measure of the ‘performance’ of the participants when discriminating the action morphs on a particular quality. Low JNDs indicated high sensitivity to the action quality, whilst high JNDs indicated poor sensitivity to that action quality.

*Results*

At this point we have collected data from 16 participants. We will continue to collect the rest of the data over the coming months, aiming to complete the preparation of a paper by summer 2023. For the data we have collected so far, the mean JNDs for each action quality and set of action morphs was calculated. We then averaged the JNDs for when the task of the participant and the morph continua did not match (different); here we expected performance to be poor, and less than performance when the task and continua matched (same; see Figure 5). Although at this point it is not possible to conduct inferential statistics, it is apparent that participants were better at judging the qualities on which the actions varied most.

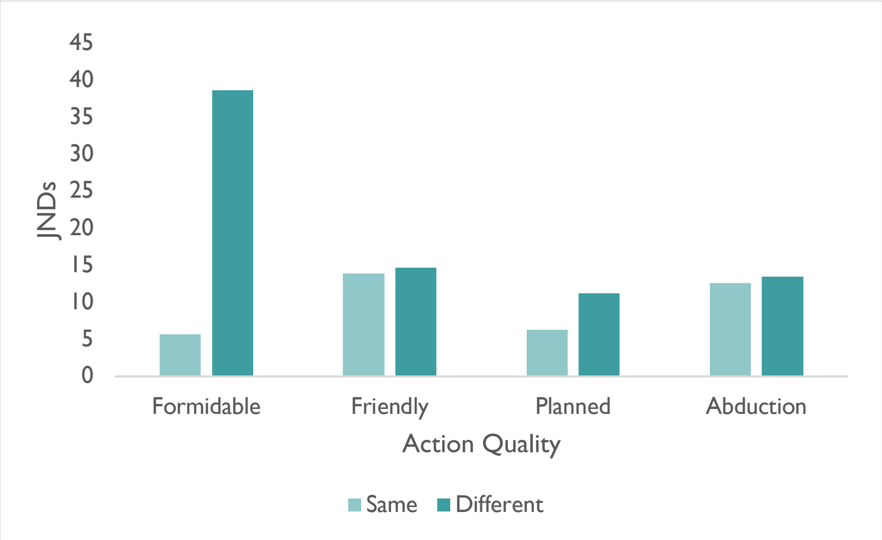


Figure 5. Ability to discriminate action qualities from morphed actions. JNDs represent perceptual performance, here low values indicate high performance, whilst high values represent poor performance. Light blue bars (same) are when the participants are discriminating the same quality on which the actions vary. Dark blue bars (different) are when the participants are discriminating other qualities than the quality on which the actions vary.

In addition, we examined the effect of autistic traits on the ability of individuals to discriminate different actions. Because at this point we have not tested enough participants to examine the ability of participants to discriminate each of the action qualities separately, here we examine perceptual performance more generally. After calculating AQ scores for each individual, the average AQ was 20. We then plotted the ability to discriminate actions on the quality on which they varied against AQ scores (see Figure 6). It is difficult to interpret a trend at this point, however, the data currently suggests that higher accuracy is associated with a higher degree of autistic traits.

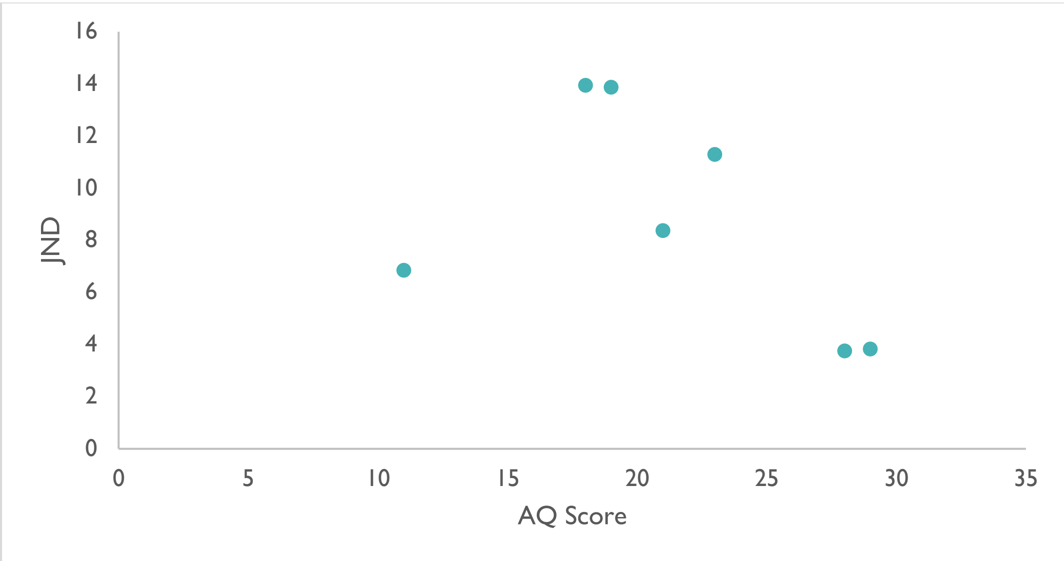


Figure 6. Action discrimination as a function of AQ.

## Discussion

So far, the data collected is largely in line with our predictions: participants perform better when they discriminate the action quality on which the actions vary the most. However, participants appear also to be able to discriminate other action qualities even when stimuli don't vary much on that dimension. Further data will help us determine whether this is just a characteristic of the participants we have tested to date, or whether this because even small variance in other action qualities can easily be picked up.

Previous research has stated that the general non-autistic population score lies between 15-26 (Baron-Cohen et al., 2001). In the data we have collected, we found that the highest performances were recorded by individuals that scored over

28 in the AQ (e.g. 3.74 = 28; 3.83 = 29). This might suggest that our aim to evaluate action perception in terms of autistic traits might point in the direction that autism enhances action perception, despite previous well-documented research describing psychological deficits. This research is ongoing, and the collection of data will continue through the coming months. We expect additional data to help clarify the patterns we have observed to date.

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