"Autistic-like" Personality Traits in Neurotypical Adults: Examining Possible Differences in the Ease, Speed and Hierarchy of Social Inference

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Abstract

This study tested the hypothesis that traits associated with high-functioning autism and Asperger Syndrome exist in normally-functioning adults and that people with pronounced traits of this kind show a systematic deficit in the ease, speed and hierarchy of social inference. We also explored whether these traits related to other known measures of personality. A sample of fifty-nine undergraduate and graduate students on the University of Oregon campus participated by completing five social inference tasks, the Autism Spectrum Quotients (AQ) and the Big-Five Mini-Markers. Comparisons of these measures failed to support the proposed hypothesis, but the results raise questions about the validity of the AQ to be much more than another measurement of known personality types. The results also suggest an organization of multiple social inferences, though robust, that may have some susceptibility to variation due in part to individual differences. Lastly, this exploratory study provides suggestions for further research.

Introduction

Hardly a moment passes in our daily lives when we are not attempting to figure out what is on the minds of others by interpreting their behavior. For many, the act of inferring the mental states comes naturally, but for those who display more autistic-like personality traits, it may be a far more difficult task. People who successfully "read" the minds of those around them without effort might not realize how important these interpretations can be. In fact, the world would be a dangerous and lonely place without this ability; our capacity to infer mental states allows us to connect with the minds of others and to understand the subtle gestures that provide potentially vital information about dangers in our immediate environment. For example, is the meaning of a stranger's hands waving at a busy street corner a friendly gesture or a warning of approaching doom as an out-of-control vehicle careens towards us? Most people are quickly able to find the correct interpretation, perhaps by looking carefully at the person's facial expression or by considering contextual information. On the other hand, some people are puzzled by that type of behavior and even with much information cannot find the puzzle's solution. People at the latter extreme are those with autism, a pervasive developmental disorder that, among other deficiencies, robs individuals of the ability to fully appreciate the working and meaning of mental states.

The ability to interpret behavior by reference to mental states is often referred to as Theory of Mind (ToM), and includes the network of folk concepts that allows people to identify and reason about emotions, goals, intentions, and other mental states and relate them to observed behavior (Malle & Holbrook, in press). The ability to make these inferences is crucial to the ability to function in a social world. Living in social communities also requires making inferences about personality traits and social roles as well as forming evaluations and moral judgments (Malle, 2007); those inferences allow us to understand our world and our perceived place in it.

Autistic individuals are usually studied for their "mindblindness" (Baron-Cohen, 1995), or the deficiencies in inferring mental states in others and themselves. The present project expands on this topic of research in two directions. First, it examines nonclinical populations who may vary in their expression of "autistic-like" personality traits (e.g., the frequency of related traits they possess). Second, this study measures a broad range of inferences (about mind, gender, personality, and morality) and investigates whether performance on these measures varies with differing degrees of autistic-like personality traits displayed in neurotypical adults.

The Autism Spectrum and ToM

Children and adults who have been diagnosed with high-functioning autism (HFA) or Asperger Syndrome (AS) lack, to some degree, the ability to infer mental states in others (Austin, 2005). Nevertheless, some children who have been diagnosed with autism still manage to be successful at the false-belief task, a basic tool used to measure ToM (Tager-Flusberg, 2007). Similarly, family members of individuals diagnosed with Autism also demonstrate a deficit in ToM compared to members of families without a history of autism (Baron-Cohen & Hammer, 1997). The latter families, however, perform quite well on an embedded figures task, a measurement of one's ability to attend to detail.

Despite the fact that HFA and AS have historically been diagnosed categorically, the documented but seemingly inconsistent observations have led some researchers to question whether autism represents a spectrum or continuum of personality features, from mild to extreme, that are already present in the general population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001a). Indeed, a growing body of research suggests that a "broader phenotype" of autism or "autistic-like" personality traits exists in the nonclinical population (Baron-Cohen et al., 2001a). These traits include deficits in attention switching, imagination, social skills, communication, and increased ability in attention to detail, also characterized as enhanced focus of attention. In other words, we may all be a little autistic, but the degree to which these proposed "autistic-like" personality features are present in nonclinical populations and their relationship to deficits in ToM remain in question. Still, many researchers believe that deficits in language and reciprocal social communication (key elements of an HFA or AS diagnosis), are simply the extremes on a continuum of the personality features that may result in a weak or non-existent theory of mind (Austin, 2005; Baron-Cohen et al., 2001a; Mason, Williams, Kana, Minshew, & Just, 2008; Tager-Flusberg, 2007; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005).

To measure the presence of these traits in the general population, Baron-Cohen et al. (2001a), presented the Autism Spectrum Quotient (AQ). The AQ is a self administered questionnaire designed to measure "autistic-like" personality features in individuals with normal intelligence. In the initial development of the AQ, Baron-Cohen and colleagues tested individuals diagnosed with HFA and AS against nonclinical populations made up of students, math Olympians, and a random control group.

Clear differences in the frequency of "autistic-like" personality features (from here on labeled A-traits), as measured by the AQ, were evident in this British population. The group of HFA and AS individuals scored significantly higher ($M = 35.8$, $SD = 6.5$) than all nonclinical populations tested. Still, the nonclinical groups showed systematic differences in their scores. Other research has found similar correlations between systematic and convergent thinking in mathematicians and individuals with HFA and AS (Nettle, 2005). Therefore, it may be no surprise that math Olympians ($M = 24.5$, $SD = 5.7$) scored closest to the HFA/AS group while the student group (M = 17.6, SD = 6.4) and random control (M = *16.4, SD* = 6.5) scored significantly lower. Further, within the student group was a continuum of scores. Students whose majors were in the physical sciences (mathematics, computer science, physics) scored higher than those in the humanities, and the latter scored slightly higher than those with majors in the social sciences. In a similar study, Focquaert, Steven, Wolford, Colden, and Gazzaniga (2007) compared Dutch humanities and science students using the Empathy Quotient (EQ) and the Systemizing Quotients (SQ). Both quotients measure traits associated with the autism spectrum, such that people diagnosed with autism score lower on the EQ and higher on the SQ (Baron-Cohen et al., 2003; Baron-Cohen & Wheelwright, 2004). Focquaert and colleagues found that humanities students scored higher on the EQ and lower on the SQ than did science students. Results like these seem to indicate that A-traits can be found distributed among the general population, in a systematic fashion, such that those who are more inclined to use abstract ideas and multi-answer solutions gravitate to areas of study that complement their respective systems of problem solving.

Clearly, if A-traits are related to deficits in ToM and the AQ is measuring A-traits in the general population, we should expect to find a relationship between varying deficits in ToM that correlates with variations in the frequency of AQ scores. For example, we might postulate that if mathematicians do, indeed, display more A-traits, their ability to assume the mindset of others may be more difficult or may manifest itself differently than it would in participants from the social sciences and other areas outside of the sciences.

To explore a similar question, Kunihira and colleagues (2006) used Japanese participants and compared their AQ scores with their scores on the revised version of the "Reading the Mind in the Eyes Test" (RMET) to explore whether A-traits related to deficits in ToM. The revised version of the RMET is an "advanced theory of mind test," that evaluates the ability of participants to interpret the mindset of others by viewing pictures of the eye region of actors and actresses and matching the visual expression to one of four adjectives placed around the picture (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001b, p. 241). Despite the RMET's capacity for distinguishing HFA and AS participants from nonclinical participants (Baron-Cohen et al., 2001b), the researchers were unable to correlate degrees of A-traits (e.g., AQ scores) and differences in ToM. Kunihira and colleagues, however, noted that the RMET may not have been sensitive enough to find significant differences in ToM in this Japanese population. Also unclear is whether cultural tendencies may have affected the results. Therefore, the issue is far from being resolved and requires further examination with multiple cultural groups and with more sensitive measures.

Another issue that remains unclear is whether deficits in ToM are related to deficits in higher-order-rule use and executive functioning rather than a domain-specific impairment (Zelazo, Jacques, Burack, & Frye, 2002). One way to approach this issue is to assess people who vary in A-traits (e.g., science majors and social science majors) across a wider range of social inferences. That wider range assessment would go beyond merely mental state inferences to include inferences of social categories, personality, and moral values. Previous work found little difference between neurotypical children and those diagnosed as autistic and their abilities to make moral judgments (Grant, Boucher, Riggs, & Grayson, 2005). That research, however, typically measured the content of people's answers to the moral puzzles, not the cognitive process by which they solved the puzzles. Individuals diagnosed as HFA/AS may follow reasoning rules to arrive at moral judgments without having the kinds of moral sentiments or making the kinds of mental-state inferences that guide the judgment of most people as they assign praise, blame, and punishment. Also, the goal/desire inferences seem less affected by autism than inferences about beliefs and complex emotions.

Measuring Social Inference: A More Sensitive Measurement of ToM

Smith and Miller (1979) found that they could measure what was at the forefront of the mind by using participant response times. Their study probed the inferences participants made about a short behavior description. For example, PERSON probed whether participants had inferred a personality. Participants never knew which inference would be probed; therefore, the time they took to answer each probe was a reasonable estimate of how accessible (and perhaps important) the probed inference was. In general, inferences that participants could make or retrieve more easily produced shorter response times. Building on that work, Smith and Miller (1983) examined what types of inferences generated quick responses. They found that inferring gender—not a mental state, but a category and type of social inference nonetheless—was faster than inferring intentionality, and that inferring intentionality was faster than inferring personality traits. Subsequent research on "spontaneous trait inferences" never compared those inferences with any other types of inferences. If earlier research had made those comparisons, perhaps the spontaneity of traits would have paled in comparison with that of other inferences. In this study, we attempt to fill that gap.

Holbrook (2006) extended the paradigm of exploring inferences by using video stimuli, streamlining the probing process, making the stimuli more natural, and tapping into people's everyday abilities to interpret behavior. He compared five inferences about gender, intentionality, goals, belief, and personality traits. The results of four studies suggested a hierarchy of social inference in which gender is the easiest and fastest inference to make. Intentionality and goals are almost as easy and occur almost as quickly as gender inferences, but beliefs and personality traits were less often and less quickly inferred (Malle, 2007). Nonetheless, Holbrook excluded inferences about emotions and moral judgment.

The Current Study

Researchers involved in previous studies assumed that individuals were equally capable of making social inferences. To date, however, no one has attempted to link individual differences to variations in making inferences. Furthermore, because of the theoretical relationship between A-traits and ToM, this study will evaluate whether differences are evident between neurotypical adult participants who display more autistic-like personality traits than others.

In addition, questions arise regarding the extent to which the AQ relates to the Big Five personality types (Wakabayashi, Baron-Cohen, & Wheelwright, 2006). Wakabayashi and colleagues, for example, compared a population of Japanese participants in this domain using the AQ and the NEO-PI-RI. They found that the Big Five could account for only 24% of the variance in AQ scores. Specifically, they found a moderately negative correlation between the AQ and extroversion, a small negative correlation with conscientiousness, as well as a small positive correlation with neuroticism (the inverse of emotional stability). In light of these minimal correlations, the researchers suggested that A-traits may represent extreme features outside the established personality types. Because of the minimal results in this domain, further exploration seems worthwhile. This study will, therefore, attempt to clarify which specific subcategories of the AQ (attention switching or imagination) correlate with subcategories of the Big Five (Openness, Emotional Stability, and Extraversion). Moreover, by using measurements of the Big Five and A-traits, we may better understand the nature of individual differences in mental state inference. Finally, we will compare Big Five scores, scores of students with differing areas of study, and AQ scores, both jointly and independently, to try to determine any relationships these measures may have with mental state inferences in five chosen tasks.

Because researchers have conflicting interpretations about the nature of HFA, AS, A-traits and their relationships with ToM, and the relationship between different measures of social inference, the present study will seek to address the following questions:

- Are normally-functioning adults who display more "autistic-like" traits less likely to infer mental states when observing the behaviors of others?
- Do subcategories of the AQ relate to different types of social inference?
- Do these inferences about intentions, goals, beliefs, and thoughts fall into a hierarchal order that is the same or different from that of average individuals?
- Do the AQ and its subcategories relate to subcategories of known measurements of personality?
- Do the AQ and a personality assessment jointly or independently predict people's ease, speed, and hierarchy of social inferences by examining personality types?

Predictions

Body and behavior-based inferences of gender and intentionality should not be difficult for people with a high frequency of A-traits. These interactions are readily available in most instances and create a "rich knowledge structure" from which to draw intentional inferences (Malle, 2007, p. D-5). In addition, goal inferences rely on the easily-viewed physical behaviors of a target in relationship to a goal object (Malle, 2007; Wellman & Phillips, 2001). Perhaps individuals who display more A-traits have certain skills (superior visual-attention, systematic and convergent thinking) that may help the ease and speed of inferring goals (Baron-Cohen et al., 2001a; Nettle, 2005; Tager-Flusberg, 2007). Therefore, goal inferences may not be problematic if they are understood as "tendencies to act."

Mental-state inferences about thinking or beliefs are similar in that they are high in variability and have no physical cues that can be observed (Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006; Malle, 2007) and should be similar to each other in the ease and speed with which subjects infer them. Therefore, mind based inferences, should be difficult for people with pronounced A-traits but such inferences are more difficult for average people.

Personality or trait inferences should prove difficult and slow. Trait inferences require the perceiver to build on the intentionality as well as the mental-state inferences about that behavior (Malle, 2007). Other findings have suggested that trait inferences can be made spontaneously while encoding a trait-eliciting stimulus, suggesting that these inferences are automatic and can be made without the awareness of the perceiver (Winter, & Uleman, 1984). Nevertheless, no evidence in the literature addresses a relationship between trait inferences and autism. Similarly, little is known about the tendency of autistic persons to blame or praise the behavior of others (i.e., make moral judgments).

Researchers disagree about the difficulty of making moral judgments (assigning blame and praise). Some believe that moral judgments are quick and easy because perceivers relay on salient moral-emotion cues (Haidt, 2001). Other researchers have suggested that making moral judgments takes a conscious effort that requires the processing of information from a number of sources that are at times vague. Therefore, moral judgments and inferences about emotions may take even more time than other inference types (Malle, 2007; Winter & Uleman, 1984).

Method

Participants

Participants were 59 undergraduate and graduate students at the University of Oregon in Eugene, 35 of whom were males. The age of all participants ranged from 18 to 60 ($M = 24.24$, $SD = 8.91$). The participants were recruited from all areas of study with the use of class visits, email, flyers distributed to departments, and announcements posted in high-traffic areas around campus. All recruitment efforts noted that participants would receive a cash incentive of eight dollars.

Materials

To test whether deficits in the ease, speed and hierarchy of social inference are associated with area of study, frequency of A-traits present in a nonclinical population and personality types, the following equipment, software, and research materials were used: four IBM desktop computers; four head-mounted microphones manufactured by Sennheiser; *Presentation* version 11.3, software by Neurobehavioral Systems Inc.; MediaLab V2008.1.2 software, written by Blair Jarvis, copyrighted by Empirisoft Corp.; Microsoft Excel 2007 spreadsheet software for presenting the Mini-Markers; Microsoft Word 2007 word processing software for presenting the SAMSI as well as the recording of demographic data and consent forms.

Design and Procedures

No more than four participants at a time were invited to the lab to participate in an experimental session that lasted 45 to 60 minutes.

Participants signed informed consent forms, indicating that they understood their rights as human subjects including the right to discontinue participation at any time. Participants were informed that, with their permission, their verbal answers to some questions would be recorded. They were then asked to indicate the extent to which their answers could be used for further study. Upon submitting their signed consent forms, participants were placed in one of four testing rooms, given verbal instruction, and asked to complete a series of tasks.

For the first task, participants read the "Short Assessment for Mental State Inferences" in the "Narrative Representation of Social Interaction (SAMSI)" developed by Malle and Rogers (2008). The SAMSI was designed to measure the number of social inferences participants make about the thoughts and feelings of characters in a social interaction even when no mental-state information is given in the narrative itself. After a distraction period, during which they completed the remaining measures, participants were then asked to retell the story and to explain its meaning. The purpose of this measure was twofold. First, the SAMSI was an additional measurement to assess the relationship between the A-traits and social inference. Second, the SAMSI was used to compare groups (Social and Science Groups) for differences in social inference. The major dependent variable in the SAMSI was the number of adjectives used to describe the mental states or traits of the main characters. In addition, inferences about feelings, desires, thinking and personality were secondary dependent variables.

Our primary method of measuring social inference adopted procedures from Smith and Miller (1979) and Holbrook (2006). Participants viewed short video clips, using Presentation 11.3 software, with three sets of 12 stimulus behaviors: trait-tailored, goal-tailored, and untailored. The trait- and goal-tailored sets were adapted from previous studies that used sentences rather than videos (Hassin, Aarts, & Ferguson, 2005; Winter & Uleman, 1984). An additional set of 12 untailored clips allowed for any inference in principle. The result was 36 stimulus videos: 12 designed to elicit trait inferences, 12 to elicit goal inferences and 12 untailored videos. Also, eight practice trials, one catch trial (which instructed participants not to respond), two emotional catch trials, two intentionality catch trials (unintentional behaviors), and three control trials (which asked about emotions) were added to the mix. The first catch trial was designed to ensure that participants were not automatically responding after every behavior. The intentional catch trials were designed to ensure that participants were making meaningful responses. The emotional control and catch trials were matched with untailored behaviors and used for exploratory purposes.

In total, 52 videos were presented in one of five different sequences to counterbalance video and data bias. Therefore, the 36 experimental stimulus behaviors and the four main experimental question cues were balanced so that each participant was probed for each inference cue nine times, three times for each of the three behavior types. The presentation of the eight practice videos, however, was always first; the 11th and 23rd videos were always an unintentional catch trial; the 18th and 25th videos were always catch trials; the 14th, 30th, and 47th videos were always emotional control trials. All videos were displayed on a CRT monitor for 4 to 12 seconds. All question cues were displayed in a yellow font on a black background for three seconds after the video and doubled as the maximum response time.

For each video, participants were asked one of five random questions: did the main actor intentionally (INTENTION?) perform the behavior depicted in the video; can an observer detect the main actor's goal (GOAL?) in the situation; does the main actor reveal a personality trait (PERSONALITY?); can an observer detect what the main actor was thinking (THINKING?);

does the main actor reveal an emotion (EMOTION?) in the situation. To respond to these question cues, participants used the number pad located on the right-side of the keyboard. In rooms one and three, participants pressed the "2" key for a "yes" response, or the "1" key for a "no" response; participants in rooms two and four pressed the "1" key for "yes" and the "2" key for "no." This counterbalancing ensured that response times were independent of the keys used to respond to a question. In addition to verbal instruction for the response procedure, note cards with the words "YES," written in green, and "NO," written in red, were placed above the corresponding keys while covering the remaining keys. Also, headphones equipped with microphones placed directly in front of the mouth were used so that the participants could listen to any verbal information presented in the videos and, after their yes/no responses, provide explanations of what they had detected in the video. The dependent variables for this measure were the percentage of yes/no responses for each question cue (ease) and their subsequent response times (RT) (speed).

The primary portion of the study crossed two within-subject factors: behavior type (trait-tailored, goal-tailored, and untailored) and inference cue (intentionality, goal, thinking, and personality). Emotion represented a fifth inference cue for exploratory comparison (its corresponding behaviors were untailored). Participants received cues in five forms such that each individual sentence was paired with each cue exactly once. Forms were randomly assigned to participants.

Our secondary method of measuring social inferences also adopted the procedure from Smith and Miller (1979). Participants read stimulus sentences, using Presentation 11.3 software, with five sets of four stimulus behaviors: intentionally positive, unintentionally positive, intentionally negative and unintentionally negative. The result was 30 stimulus sentences structured so that five questions related to each of the above stimulus behaviors and elicited inferences in each category. The remainder of the 30 questions consisted of five practice trials, two catch trials (which instructed participants not to respond), and three control trials (which asked about gender: ISMALE?). The first catch trial sought to ensure that participants did not automatically respond after every behavior while the control trials ensured that participants were making meaningful responses.

To assure proper counterbalancing, all 30 sentences were presented to participants in one of five different sequences so that the 20 experimental stimulus behaviors and the four main experimental question cues were balanced and each participant was probed for each inference cue four times, and five times for each of the four behavior types. Forms were randomly assigned to participants, but because of problems with the programming, complete balancing of the cues and behavior types were corrupted.

All sentences were displayed in white font on a CRT monitor for 4 to 12 seconds; all question cues were displayed in a yellow font on a black background for three seconds after the sentence was displayed. The time also doubled as the maximum response time. For each sentence, participants were asked one of six random questions: did the main actor intentionally (INTENTION?) perform the behavior, could the main actor's goal (GOAL?) be detected in the situation, could the main actor's thinking (THINKING?) be detected, can the gender of the main actor (ISMALE?) be determined, or were the actions of the main actor worthy of blame (TOBLAME?) or praise (TOPRAISE?). Generally, the response procedures were identical to those used for the video stimuli. The exceptions involved the blame and praise questions for which participants were instructed to rate the blame and praise on a 0 to 5 scale such that "5" indicated great praise or blame and "0" indicated no blame or praise. The dependent variables for this measure were the yes/no responses and their subsequent response times (RT).

The revised version of the "Reading the Mind in the Eyes" Test (RMET), an "advanced theory of mind test," also helped to evaluate the ability of participants to make mental state inferences (Baron-Cohen, et al, 2001a, p. 241). The revised RMET consists of 37 pictures (the original used only 25) of the eye regions of different actors and actresses. For the current study, the RMET was modified to use only the first 18 pictures. The researchers felt that 18 responses would be more than adequate to draw valid comparisons, and the RTs would increase the sensitivity of the measure. The RMET was displayed using MediaLab, a technique that allowed the automatic recording of answers and reaction times (RTs). To complete the task, participants chose one of four displayed adjectives that they believed best described the thought or feeling the actor or actress was expressing. Participants used a computer mouse to select an adjective for each picture. For every correct answer, participants were given one point; no points were given for false answers. The total number of correct answers was the main dependent variable; RTs were the secondary dependent variable.

Following completion of the RMET, participants viewed and responded to three cartoons. They were asked to describe what was occurring and to indicate why the cartoon was supposed to be amusing. The main dependent variable for this measure was the accuracy in describing what was happening and why it was amusing (see appendix for scoring procedure). The scoring procedure assigned one point for accurately describing the event in the cartoon and one point for why it was supposed to be amusing. Therefore, participant's scores could range from 0 to 2 for each cartoon. The number of mental-state inferences each participant made about the characters in the cartoon became an additional indication of the frequency of spontaneous inferences.

The Autism Spectrum Quotient (AQ) assessed the frequency of A-traits of participants. The AQ is a self-administered questionnaire designed to measure the extent to which traits associated with the autism spectrum are present in normally-functioning adults (Baron-Cohen et al., 2001b). The AQ consists of 50 questions divided into five subcategories with 10 questions each: social skills, communication, imagination, attention switching, and attention to detail. All questions require a response on a 4-point, forced answer, Likert scale ranging from "definitely disagree" to "definitely agree." One point is given to any response that is consistent with "autistic-like" behavior regardless of degree; while the opposite responses were given no score. No extensive norms exist for the test, but scores of 32 or above are generally seen in individuals who had been previously diagnosed with High-Functioning Autism (HFA) or AS (Woodbury-Smith et al., 2005).

Finally, to assess whether certain personality traits are related to the AQ and differences in social inference, the Big Five personality types (Extroversion, Agreeableness, Conscientiousness, Emotionality Stability, and Openness to experience) were measured using the "Mini-Markers" developed by Saucier (1994). The 40-question survey was adopted from Goldberg's (1992) 100 robust Big Five adjectives. Despite the limited number of adjectives used in the Mini-Markers, it seems to be both a valid and reliable measure of the Big Five (Saucier, 1994; Dwight, Cummings, & Glenar, 1998). The 40-question survey is divided into sections, such that each personality type is represented by eight adjectives. Some adjectives are positively correlated, while others are negatively correlated. To complete the task, participants rated each adjective on a 9-point Lickert scale, from "1 = extremely inaccurate" to "9 = extremely accurate," based on how well they felt that adjective described themselves. The mean score for each personality type was calculated by summing all positively correlated and negatively correlated scores and dividing the result by eight.

Results

Measurements of Social Inference

Ease and Speed of Inference for Video Stimuli

The percentage of "yes" answers within each cell of the 3 x 4 design was the necessary first step to assess ease of inference. The percentage calculations ignored missing values (no answer) because they could not be clearly classified. A within-subject MANOVA test completed the analysis of the percentages.

An assessment of speed of inference focused on the average response times for "yes" responses within each cell of the design. The response times reflected average latency for saying "yes" to the goal cue in response to untailored behaviors. The analysis excluded individual latencies below 511ms because they were significantly outside the main distribution of data. If participants failed to answer "yes" in some cells, no information existed about latencies for responses making it necessary to complete sample mean-replacements for those cells. Of the 59 cases, only two were rejected due to the volume of missing data. The next step in the analysis of this variable involved a within subject MANOVA test.

The MANOVAs for both variables assessed the effects of inference cues separately within each behavior type in order to examine the possible unique patterns each type displayed. The inference cue factor typically decomposed into three orthogonal contrasts: intentionality vs. goal; thinking vs. average of intentionality and goal; and personality vs. average of thinking, goal, and intentionality. Helmert contrasts within each behavior type (intentionality vs. average of goal, thinking and personality; goal vs. average of thinking and personality; personality vs. thinking) added a necessary layer of comparative information. For all contrasts we report the results of univariate *t*-tests.

Within the untailored (Figure 1) and trait-tailored behaviors (Figure 2), participants found goal inferences ($M = 94.7\%$ for untailored; $M = 93\%$ for trait-tailored) easier to make than intentionality inferences ($M = 86.3\%$ for untailored; $M = 75.7\%$ for trait-tailored; for untailored, $t(168) = 2.64$, $p = .01$; for trait-tailored, $t(168) = 3.94$, $p < .001$). For goal-tailored behaviors (Figure 3), however, no significant difference existed between goal ($M = 92.4\%$) and intentionality ($M = 94.2\%$) inferences [$t(168) = .33$, $p =$ ns]. A comparison of goal inferences, to the average ease of thinking inferences ($M = 55\%$ for untailored, $M = 71.6\%$ for goal-tailored, $M = 73.4\%$ for trait-tailored), and personality inferences ($M = 45.9\%$ for untailored; $M = 46.2\%$ for goal-tailored; $M = 78.9\%$) revealed that participants still found goal inferences easier to make regardless of behavior type [for untailored, $t(168) = 9.61$, $p < .001$; for goal-tailored, $t(168) = 8.93$, $p < .001$; for trait-tailored, $t(168) = 6.25$, $p < .001$].

A comparison of intentionality inferences, and the average of goal, thinking and personality for untailored behaviors showed that intentionality still appeared easier [$t(168) = 5.46$, $p < .001$], as it did for goal-tailored behaviors [$t(168) = 6.79$, $p <.001$]. Nevertheless, no significant difference existed between intentionality and the average of goal, thinking and personality for trait-tailored behaviors [$t(168) = 1.3$, $p =$ ns].

Data revealed that participants clearly found thinking inferences more difficult than the average of intentionality and goal across all behavior types [for untailored, $t(168) = 6.53$, $p < .001$; for goal-tailored, $t(168) = 4.8$, $p < .001$; and for trait-tailored, $t(168) = 2.65$, $p = .01$]. On the other hand, participants found thinking inferences much easier to make than personality inferences for goal-tailored behaviors [$t(168) = 4.59$, $p < .001$]. Still, for untailored behaviors, thinking inferences became marginally easier than personality inferences [$t(168) = 1.82$, $p = .07$]. See Figures 1 and 2. For trait-tailored behaviors, participants made personality inferences more easily than thinking inferences, though not significantly [$t(168) = 1.03$,

p = ns]. Personality inferences, when compared to the average of all other inference types, were much harder for participants considering untailored behaviors [$t(168) = 7.21, p < .001$] and for goal-tailored behaviors [$t(168) = 8.53$, $p < .001$]. The pattern of difficulty changed, however, for trait-tailored behaviors ($t(168) = .4$, p = ns). See Figure 4 for overall means.

For untailored behaviors (Figure 5), participants showed latencies (speed) for intentionality inferences (M = 1527.68 ms) that were nearly identical to those for goal inferences [M = 1549.07, $t(174) = .35$, p = ns]. Participant latencies for thinking inferences (M = 1634.35) were, however, greater (slower) than the average of both intentionality and goal inferences [$t(174) = 2.05$, $p = .045$], while personality inferences (M = 1777.81) were much greater than the average of the first three [$t(174) = 3.65$, $p < .001$]. Also, latencies for intentionality inference were less (faster) than the average of the other three [$t(174) = 2.6$, $p = .01$]. Similarly, goal inference latencies were less than the average of thinking and personality inferences [$t(174) = 2.65$, $p = .01$]. Participant latencies for thinking were also less than latencies for personality inferences for untailored behaviors [$t(174) = 2.5$, $p = .02$].

For goal-tailored behaviors (Figure 6), participant latencies for goal inferences (M = 1495.58) were less (faster) than those for intentionality inferences [M = 1644.72, $t(174) = 2.08$, $p = .042$]. Latencies for thinking inferences (M = 1641.94), however, were not significantly greater than the average of intentionality and goal [$t(174) = 1.29$, p = ns], and personality inference latencies (M = 1967.13). Similarly, latencies for untailored behaviors, were significantly greater than the average of the other three [$t(174) = 6.9$, $p < .001$]. Latencies for intentionally inference, however, were not significantly less (faster) than the average of all other latencies [$t(174) = .92$, p = ns]. While latencies for goal inferences were less than the average of thinking and personality latencies [$t(174) = 5.75$, $p < .001$], latencies for thinking inferences were less than personality inferences [$t(174) = 5.06, p < .001$].

For trait-tailored behaviors (Figure 7), participants made intentionality inferences ($M = 1439.5$) faster than goal inferences [$M = 1660.2$, $t(174) = 4.05, p < .001$] and significantly faster than the average of goal, thinking and personality inferences [$t(174) = 7.01, p < .001$]. Participant goal inferences were faster than the average of thinking and personality inferences [$t(174) = 2.05$, $p = .45$], but thinking inferences were significantly slower than the average of intentionality and goal inferences [$t(174) = 4.6, p < .001$]. Personality inferences, on the other hand, caught up to the other inferences for trait-tailored behaviors and were no longer significantly slower than thinking inferences [$t(174) = 1.12, p =$ ns], or the average of intentionality, goal and thinking [$t(174) = 1.42, p =$ ns]. See Figure 8 for overall means.

Ease and Speed of Inference for Sentence Stimuli

For the sentence stimuli, cue and behavior type imbalances made crossings of the within-subject factors impossible. Consequently, the design of the study shifted to a pseudo-between-subjects analysis. Therefore, for thinking and goal cues, ease and speed for all cases of intentionally-positive behaviors were compared to all cases of intentionally-negative behaviors. Some checks on the data involved comparing cases of praise for intentionally-positive behaviors to cases of unintentionally-positive behavior and cases of blame for intentionally-negative behaviors to cases of unintentionally-negative behaviors. Data analysis also included comparing cases of praise for intentionally-positive behaviors to cases of blame for intentionally-negative behaviors. The percentage of yes/(yes + no) answers allowed an assessment of ease of inference. The average response latencies for yes-responses measured speed of inference. Data analysis excluded individual latencies below 511ms because they lay outside of the main distribution of data. Multiple one-way analyses of variance (ANOVAs) allowed a comparison of the cases described above.

Participants found inferences of intentionality significantly easier to make when behaviors were intentionally positive ($M = 91\%$) than when the behaviors were intentionally negative [$M = 70\%$, $F(1, 90) = 6.71$, $p = .01$]. Similarly, participant latencies for making inferences about intentionality were less (faster) for intentionally positive behaviors ($M = 1272.65$ms) than for intentionally negative behaviors [$M = 1530.37$, $F(1, 76) = 6.99$, $p = .01$]. Thus, people are better and faster at determining the intentionality of a behavior that has positive connotations.

A similar pattern revealed itself regarding goals. Participants found inferences about goals easier when behaviors were intentionally positive ($M = 95\%$) than when behaviors that were intentionally negative [$M = 65\%$, $F(1, 107) = 18.18$, $p < .001$, $F(1, 94) = 5.43$, $p = .02$]. Also, participant latencies for goal inferences were significantly less (faster) for intentionally positive behaviors ($M = 1486. 58$) than intentionally negatively intentional [$M = 1725.36$, $F(1, 86) = 5.84$, $p = .02$]. When participants considered behaviors unintentional, negative behaviors were easier to infer ($M = 45\%$) than positive behaviors [$M = 45\%$, $F(1,82) = 1.38$, $p =$ ns], but latencies revealed no significant difference in the speed of inferences between unintentionally positive behaviors ($M = 1928.41$) and unintentionally negative behaviors [$M = 2001.45$, $F(1, 52) = .38$, $p =$ ns].

Participant inferences about thought revealed no significant difference in valence or latency for intentionally positive behaviors ($M = 84\%$, $M = 1608.62$) and intentionally negative behaviors [$M = 73\%$, $M = 1776.65$; for valence, $F(1, 78) = 1.37$, $p =$ ns; for latency, $F(1, 33) = 2.23$, $p =$ ns]. Similarly, participant responses showed no significant differences for unintentionally positive behaviors ($M = 36\%$, $M = 1867.79$) and unintentionally negative behaviors [$M = 43\%$, $M = 1995.38$; for valence, $F(1, 78) = .43$, $p =$ ns; for latency, $F(1,33) = .55$, $p =$ ns]. Thus, inferences about an actor's thoughts are equally hard across all behaviors types.

Participants found assigning praise to an intentionally positive behavior (M = 92%) significantly easier than assigning praise to an unintentional behavior [M = 26%, $F(1, 77) = 60.12$, $p < .001$]. Similarly, the speed at which they assigned praise was significantly faster for intentionally positive behaviors (M = 1320.69) than unintentionally positive behaviors [M = 1938.64, $F(1, 47) = 21.37$, $p < .001$]. Therefore, people are quicker and more likely to judge the behaviors of a target as worthy of praise when the behavior is purposeful. When participants assign blame, however, there is no significant difference between intentionally negative behaviors (M = 71%) and unintentionally negative behaviors (M = 65%), but participants were marginally faster at assigning blame to unintentionally negative behaviors (M = 1519.81) than to intentionally negative behaviors [M = 1737.15, $F(1, 61) = 2.89$, $p = .09$].

Tests to compare the ease and speed with which people assign praise to intentionally positive behaviors and blame to intentionally negative behaviors and the ease and speed for unintentional behaviors revealed that praise in instances of intentional behaviors was significantly easier for participants to assign than blame [$F(1, 77) = 6.00$, $p = .02$]. Moreover, the speed at which participants assigned praise was also significantly faster [$F(1, 64) = 14.40$, $p < .001$] than the speed at which participants assigned blame. For unintentional behaviors, however, the reverse was true. People assigned blame significantly easier, and faster, than praise [for valence, $F(1, 880) = 15.21$, $p < .001$; for latency, $F(1, 44) = 6.59$, $p = .01$]. Thus, the intentionality of a behavior has a significant effect on how people judge behaviors.

Correlations

To compare the valence (ease) and latency (speed) of sentence and video stimuli responses with all measures of A-traits and the Big Five personality types, all mean responses were collapsed across behavior types, such that the mean of intentionally inferences consisted of the mean of the RTs for untailored behaviors, goal-tailored behaviors and trait-tailored behaviors. Similarly, the mean for reaction times for intentionally inferences for sentence stimuli consisted of the mean of RTs for intentionally positive and intentionally negative stimuli. The same was true for all RTs and Y/N responses for all cues. See Figures 4 and 8 for means.

Ease and Speed of Social Inference as a Function of Individual Differences

Comparisons of scores on the AQ with the ease and speed of social inferences for the video stimuli revealed no strong trend (see Tables 1 and 2). Still, AQ "Communication," which indicates difficulties in communicating with others, had a small but significant relationship with the ease of making inference about emotion ($r = .294$, $p < .05$) and the speed of reacting to emotional stimuli ($r = .315$, $p < .05$). Thus, as self-described deficits in communication increase, so did the difficulty of making emotional inferences. The speed with which participants made inferences also increased, if only slightly.

The data revealed few correlations between sentence RTs and the AQ, but AQ "Attention to Detail" was slightly related to RTs for intentionality ($r = -.313$, $p < .05$). Also, AQ "Attention Switching" was moderately related to the tendency to praise positive behavior ($r = -.421$, $p = .001$), while total AQ scores were only slightly related ($r = -.289$, $p < .05$). Nevertheless, no overall trend suggested that frequencies of A-traits, as measured by the AQ, systematically related to differences in the ease and speed of social inference for these measures.

Tests on the data detected a number of relationships between the Big Five personality types and the video and sentences stimuli. Emotional stability, for example, was significantly related to video RTs for intentionality ($r =$

.286, $p < .05$), thinking ($r = .259, p < .05$), and personality ($p = .354, p < .01$), but emotional stability was not related to the ease of inference (see Table 2). Emotional stability was also significantly related to sentence RTs for intentionality ($r = .416, p < .001$). Though not significant, emotional stability had an overall positive trend with sentence RTs (see Table 3). Thus, as emotional stability increases, so too did latency for responding to cues of intentionality, thinking, and personality.

Extroversion showed a significantly negatively correlation with emotion RTs ($r = -.291, p < .05$). On the other hand, a pattern of negative correlations, though not significant, emerged between extroversion and video and sentence stimulus RTs for intentionality, goal, thinking, and personality (see Table 1). Nevertheless, no pattern emerged between extroversion and the ease of making these inferences (see Table 2). Emotional stability was somewhat related to the ease of goal inferences ($r = 279, p < .05$), while conscientiousness was only slightly related to the ease of blame ($r = -.280, p < .05$) (see Table 4), but no relationships appeared to exist between agreeableness, conscientiousness or openness to experience and the speed or ease of any of the inference types (see Tables 1-4). Overall, these results seem to suggest that people who describe themselves as more extroverted retrieve inferences slightly faster than average, while those who describe themselves more emotionally stable retrieve inferences slightly slower than average.

Because of the number of relationships between the speed of inference and both emotional stability and extroversion, multiple regression models measured the extent to which those relationships could predict the variance of RTs. In fact, the model explained 10% of the variance in intentionality RTs of the video stimuli [$R^2 = .101$, $F(2, 56) = 2.13$, $p = .05$]; 17.5% of the variance in intentionality RTs for the sentence stimuli [$R^2 = .175$, $F(2, 56) = 5.73$, $p = .006$]; 10% of the variance in thinking RTs for the video stimuli [$R^2 = .102$, $F(2, 56) = 3.18$, $p = .05$]; and 15.6% of the variance in personality RTs for the video stimuli [$R^2 = .156$, $F(2, 56) = 5.19$, $p = .009$]. No other significant variance was predicted from this model, but with extroversion alone, a reduced model predicted more than 22% of the variance in emotion RTs [$R^2 = .226$, $F(1, 22) = 6.42$, $p = .02$].

The AQ and Big Five Personality Types

Comparisons of scores on the AQ and AQ subcategory with scores on the Big Five Mini-Markers sought to determine if A-traits, as measured by the AQ, were systematically related the Big Five personality types. The data supported the hypothesis that AQ scores would correlate negatively with extroversion and detected several other relationships. AQ "Social Skills" strongly correlated with extroversion ($r = -.662$, $p < .001$) and moderately correlated with agreeableness ($r = -.354$, $p < .01$). AQ "Communication" also strongly correlated with extroversion ($r = -.567$, $p < .001$) and moderately with agreeableness ($r = -.349$, $p < .01$). AQ "Attention Switching" moderately correlated with extroversion ($r = -.409$, $p < .001$) and emotional stability ($r = -.41$, $p < .001$). AQ "Imagination" correlated slightly with extroversion ($r = -.294$, $p < .05$) and agreeableness ($r = -.257$, $p < .05$). Overall AQ scores strongly correlated with extroversion ($r = -.641$, $p < .001$), moderately with agreeableness ($r = -.354$, $p < .01$) and emotional stability ($r = -.311$, $p < .05$). These results seem to suggest a strong relationship between the traits measured by the AQ and the Big Five personality types, especially extroversion, agreeableness and emotional stability (see Table 5).

Because the data detected strong relationships between the Big Five and the AQ, a regression model tested an *a priori* assumption that significant differences in AQ scores could be predicted jointly by levels of extroversion, agreeableness and emotional stability. Indeed, the model predicted 53.5 % of the variance in AQ scores [$R^2 = .535$, $F(3, 55) = 21.08$, $p < .001$].

AQ and the Alternative Measures of Social Inference

Comparisons of AQ scores with responses to the Assessment for Mental State Inferences (SAMSI) tested whether A-traits, as measured by the AQ, were related to the number of spontaneous inferences people made when retelling the events in a narrative when no mental-state information is given. Pearson's correlations revealed only a small relationship between AQ "Imagination" and the total number of inferences (e.g., adjectives referring to a character's thoughts, feelings, desires and personalities) a participant made when re-telling the SAMSI ($M = 7.21$, $r = -.277$, $p < .05$). Thus, the tendency to make mental-state inferences seems to have a slight relationship with participants' self reported tendency to use their imaginations. Nevertheless, no overall trend suggested that frequencies of A-traits systematically related to variations in participant's tendency to use mental-state adjectives (see Table 5).

We hypothesized that if A-traits, as measured by the AQ, were related to deficits in social inference, participants who scored higher on the AQ would be less accurate at matching a picture of the eye region of an actor or actresses with the correct adjective placed around the picture. Similarly, we hypothesized that the time needed to make that selection would be related to frequency of A-traits. Pearson's correlations provided a way to test these hypotheses and to determine if the number of accurate inferences was related to AQ score. The test, however, failed to reveal a significant relationship between AQ scores and the accuracy of these inferences ($r = -.072$, $p =$ ns). Pearson's correlations also provided a way to test whether the speed of making inferences was related to AQ scores. After excluding individual latencies greater than 9999 ms because they lay outside the main data distribution, a Pearson's correlation failed to reveal a significant relationship between these variables ($r = .138, p = \text{ns}$).

A participant's accurate interpretation of three cartoons served as an alternative measure of social inference. Specifically, the task asked participants to describe what was occurring in the cartoon and why these cartoons were supposed to be amusing. Participants received one point for accurately describing each of these aspects of each cartoon, with a total of two points possible per cartoon. The mean score for the three cartoons was the principal comparator. Overall, participants were good at this task ($M = 1.52$, $SD = .44$). In addition, the mean of the thought and feeling inferences participants made about the characters in the cartoons helped to make comparisons, but participants made few of these inferences ($M = .44$ $SD = .48$). Moreover, no relationship between the AQ and the cartoons could be detected.

Group Comparisons

Groups and the AQ

One core hypothesis was that individuals from the sciences would display more "autistic-like" personality traits (A-traits) than those from the humanities and social sciences. Participants with majors in mathematics, physics, computer science, and biology composed the Science Group (n = 29), and students with majors in the humanities, social sciences, business, art, and education composed the Social Group (n = 29). One participant, not having selected a major, was excluded from group comparisons but included for the remainder of the analyses.

A t-test was the primary method to determine whether significant differences in frequency of A-traits could be detected between the two groups. The test did not reveal a significant difference [$t(56) = 1.546$, $p = \text{ns}$]. Individuals in the Science Group ($M = 20.66$, $SD = 6.79$) did not score significantly higher than individuals in the Social Group ($M = 17.83$, $SD = 7.13$). In addition, independent samples t-tests examined differences between groups and the subcategories of the AQ. The tests revealed no significant differences between groups for AQ Social Skills [$t(56) = 1.49$, p = ns], nor for Attention to Detail [$t(56) = .062$, p = ns], Communication [$t(56) = 1.19$, p = ns] or Imagination [$t(56) = .487$, p = ns]. These finding suggest that area of study may not be a good indicator of frequency of A-traits, overall.

Groups and the Ease, Speed and Hierarchy of Social Inference

Independent-samples t-tests also helped to explore whether the ease and speed of inference differed between groups (Table 9). The tests revealed a significant difference in the ease of inferring personality between the Social Group (M =48.1%) and the Science Group [$M = 65\%$, $t(56) = -2.5$, $p = .015$]. Participants in the Science Group inferred personality more often than did the participants in the Social Group. Similarly, the ease of inferring goals from sentence stimuli were marginally different between the Science Group ($M = 75.6\%$) and the Social Group [$M = 61\%$, $t(56) = -1.93$, $p = .059$]. No other significant difference between groups, however, could be detected for the ease of inference (see Figures 9 & 10).

The data revealed no significant differences between the Social Group and the Science Group for any of the inference type RTs across stimulus types (see Figures 11 and 12). Nonetheless, the Science Group's RTs where slightly faster overall than the Social Group's RTs, though not significantly.

Groups and the Alternative Measures of Social Inference

Independent-samples t-tests compared group means for all types of mental-state adjectives used in the SAMSI, but revealed no significant difference between groups. Independent-samples t-tests also compared group means for accuracy on the RMET as well as the RTs. Once again, however, the data revealed no significant differences between groups. Finally, independent-samples t-tests compared groups on the cartoon measurements. Though the results found no significant difference for the accuracy of describing the cartoons, the Socal Group ($M = .58$) made slightly more mental-state inferences when describing the cartoons than did participants in the Science Group [$M = .31$, $t(53) = 2.12$, $p = .04$].

Discussion

Individual Differences in the Ease and Speed and Hierarchy of Social Inference

This study expands on previous research by asking whether the organization of multiple social inferences varies as a function of traits associated with the autism spectrum (A-traits) in nonclinical adults (Austin, 2005; Baron-Cohen et al., 2001b; Mason et al. 2008; Tager-Flusberg, 2007; Woodbury-Smith et al., 2005). We specifically explored whether varying degrees of the ease and speed of inferring mental states could be related to equally varying frequency of "autistic-like" personality features (A-traits). Kunihira et al. (2006) explored a similar question but failed to relate A-traits and scores on the RMET, a measurement of social inference. In their study, Kunihira et al. suggested that the failure to find a significant relationship may have been due in part to the insensitivity of the RMET. They further suggested that using reaction times in this measure might significantly increase the sensitivity.

Built on these findings, the current study measured the reaction times for sentence- and video-displayed stimuli designed to elicit multiple social inferences about such issues as intentionality, goals, and thinking, while also collecting scores and reaction times for the RMET and other measures. By including a number of measures of social inference, we hoped to create a more sensitive array that would detect individual differences in this domain. The assumption depended upon the additional measures using yes/no responses as well as measures of reaction times to assess the accessibility of the different inference types (Smith & Miller, 1979; Smith & Miller, 1983; Holbrook, 2006; Malle, 2007). Nevertheless, despite finding a few minor correlations between some of the traits and a few of these measures (see Tables 1-5), the results revealed no strong systematic relationship between A-traits and participants' ease and speed of social inferences.

Additional analysis confirmed the findings. Based on previous findings, the scores of two groups should have displayed significantly different frequencies of A-traits. For example, Baron-Cohen et al. (2001b) found that systematic differences in the frequency of A-traits could be tracked in a large population of British undergraduates by comparing groups based on their primary area of study (major). Unlike Baron-Cohen and colleagues, we were unable to find significant differences in the frequency of A-traits of individuals divided into two groups based on major (Science Group and Social Group). Of course, the current study was limited by sample size and had a mere 29 participants per group compared with the hundreds of participants per group in the Baron-Cohen study.

Nevertheless, as hypothesized, the Science Group scored higher on the AQ than the Social Group, but the difference was not significant. Likewise, the differences found in the ease and speeds of mental state inferences between these groups were minimal. Moreover, for nearly every inference type in the video and sentence stimuli, members of the Science Group made inferences slightly easier and faster than members of the Social Group. That result was unexpected. If A-traits were related to deficits in ToM, we might still have expected to see negligible differences in the ease and speed of inference that would have favored the Social

Group, but such was not the case. Only the tendency to praise was slightly easier and faster for the Social Group than the Science Group, but again the difference was not significant. These findings seem to support a folk suspicion that area of study and AQ scores are poor predictors of deficits in making mental state inferences.

Because we were unable to determine if the traits measured by the AQ are related to deficits in social inference or executive functioning (e.g., convergent thinking) it remains unclear whether deficits in ToM are related to deficits in higher-order-rule use and executive functioning rather than a domain-specific impairment (Zelazo, Jacques, Burack, & Frye, 2002). To further examine this relationship, future studies may wish to consider an alternative measure of A-traits that relates more to systemizing and convergent thinking than does the AQ. One possible measure is the Systemizing Quotient (SQ), also developed by Baron-Cohen and colleagues (2003), that some researchers have used to demonstrate the differences between these groups (Focquaert et al., 2007). To date, however, no one has attempted to determine if the traits measured by the SQ relate to deficits in social inference.

Although an analysis of the data across all measures detected no relationship between the AQ and differences in social inference, a moderate relationship became evident between extroversion, emotional stability and the speed of inference for video and sentence stimuli. In general, extroversion correlated negatively with speed of inference but positively with emotional stability. Still, no detectable relationship existed between the ease of inference and these personality types.

Because the trend between the speed of inference and personality was exclusive—ease of inference was not related to personality type—these data may be reflecting a simple pattern of predictable behavior that accompany a given trait. For example, we might postulate that one who is generally more extroverted will be more inclined to answer questions quickly, whereas people who consider themselves more emotionally stable might take additional time to deliberate before providing their answers. One way to address this question will be to analyze the manner in which participants gave their answers when inferring specific behaviors. For example, examining the time between indicating inference retrieval and the time needed to report that inference verbally might help to distinguish people who are spontaneously answering without having a specific inference in mind and those who immediately report their inferences when they come to mind. If extroversion and emotional stability do, indeed, have a significant relationship with these processes, we might expect to see systematic differences in the answers and reporting times of different social inferences as a function of these traits, such that higher levels of extroversion might relate to immediate reports, while emotional stability may relate to more thoughtful answers.

Hierarchy of Social Inference

While testing for relationships between A-traits and deficits in the ease, speed of social inference, we found support for Holbrook (2006) and Malle (2007) who suggested a hierarchal structure of social inference. Evidence from the current study revealed that, despite the frequency of A-traits, inferences relying on body and behavioral cues (categorical, intentionality, and goal) were much easier and faster than mental-state (thinking) and trait inferences (personality), as both Holbrook and Malle had predicted. The current data, however, had abnormalities. For example, Holbrook (2006) found that categorical inferences were faster than intentionality inferences; this was not the case in our study. Only when comparing differences in ease and speed of inferences from sentence stimuli was intentionality much easier and faster than categorical inferences. That result, however, may reflect the fact that in the sentences stimuli, a participant could infer gender only if the gender of the character was specified in a given sentence. Therefore, the finding most likely reflects problems in the sentence stimuli rather than a major difference from previous studies. Thus, future research efforts may need to adapt the video stimuli to accommodate categorical inferences.

We further extended the video stimuli by introducing cues to prompt emotional inferences. Participants found that emotional inferences were harder to make and took more time than all other inference types, a fact suggesting that emotional inferences are less accessible. Also, the stimuli the study used to elicit emotional inferences may have played a role in the results. For example, participants made emotional inferences only from untailored behaviors (e.g., they were not designed to elicit any particular inference), whereas the other inferences were paired with goal-tailored and trait-tailored behaviors. The tailoring had a significant effect, especially for personality inferences, such that when inference cues for personality were paired with trait-tailored behaviors, the inferences were significantly easier and faster than they were for goal or untailored behaviors, a result consistent with previous studies (Winter & Uleman, 1984). It may be that to have a better understanding of the accessibility of making inferences about emotion and its place in the hierarchy of social inference, stronger tailored stimuli are required. For example, a video that depicts a situation in which emotions are salient (e.g., a couple arguing), may promote easier and faster emotional inferences compared to a situation in which emotions are less salient (e.g., a person walking down the street).

An additional expansion of the sentence stimuli included cues to elicit moral judgments (e.g., blame and praise) to assess a possible relationship between the process of moral judgment and other inferences. While the ease and speed of the other inference types were correlated, respectively, those correlations were, for the most part, independent of the tendency to assign blame or praise. Likewise, little correlation existed between the time participants took to reach decisions about blame or praise and the latencies for other inferences. Those findings seem to suggest that the processes by which individuals answer moral questions are independent of the processes for making other spontaneous inferences. Nevertheless, as participants made moral judgments about a behavior, the ease and speed with which they did so appeared to be affected by the intentionality of the observed behavior. Therefore, according to these data, someone witnessing a negative act, despite the intentions of the target's behavior, will be quick to blame. In contrast, praising someone's behavior requires detection of deliberate positive action.

A-Traits and the Big Five

Wakabayashi et al. (2006) suggested that the traits measured by the AQ in a Japanese population have only a minimal relationship with extroversion, emotional stability, and conscientiousness. The results indicate that the AQ tapped traits that fall outside of the Big Five. To test that assertion, we used an alternative measurement of the Big Five to determine if a similar pattern could be found in a North American population. The results of this study, however, found that the traits measured by the AQ were strongly related to extroversion and moderately with agreeableness and emotional stability. In fact, those three personality types accounted for over 50 percent of the variance when regressed on total AQ scores, more than double the percentage found by Wakabayashi and colleagues. The strength of the relationship was such that it challenges the validity of the AQ to tap traits other than those in the Big Five. If that is indeed the case, a high score on the AQ could just as easily be interpreted as a representation of someone who is shy, cold, and neurotic as it could someone who may have high-functioning autism, or at least traits resembling it. These findings suggest that, rather than a measurement of traits that fall outside of the Big Five, the AQ is simply a measurement of features that can be described by known measurements of personality and may have little to do with the processes governing social inference. Further research should consider comparing the AQ with multiple measures of personality to better understand the traits the AQ measures. One reasonable conclusion, therefore, is that little relationship exists between the AQ and the ease and speed of social inference outside of those that could be detected by other known personality types.

Limitations

Some significant limitations of this study have been addressed, but others deserve to be mentioned. Primarily, the limited number of participants made it difficult to insure that we had sufficient power to substantiate early findings. We hope that with additional funds, we can recruit additional participants to increase this power.

Limitations affecting the findings stemmed from the programming used to present sentence stimuli to participants and for which participants could make inferences. The study was designed so that for each type of inference participants would see a video-displayed sentence designed to elicit a negative response or a positive response. Unfortunately, some aspects were overlooked in the programming. Corrections already in process should address this problem so that future participants will have the proper counterbalancing of these measures.

Because the analysis of the SAMSI and the cartoons required the coding of answers to open-ended questions, additional coders would have been an asset. Unfortunately, no other personnel were available for coding. For future analysis, additional coders will be recruited to insure accurate analysis of these data.

Conclusion

This initial data analysis failed to support the hypothesis that deficits in the ease, speed and hierarchy of social inference systematically relate to varying frequencies of "autistic-like" traits in a nonclinical population. Still, we did find that extroversion and emotional stability had inverse relationships with inference retrieval times. These early results raise questions not only about the validity of the AQ as something more than another measurement of personality, but also suggest that an organization of multiple social inferences, though robust, may have some susceptibility to variation due in part to individual differences. While this study is ongoing, further research will also be needed to confirm or to add clarity to these early results.

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Table 1: *Correlations for Speed of Inference (Video Stimuli RTs)*

Variable	Intentionality (RTs)	Goal (RTs)	Thinking (RTs)	Personality (RTs)	Emotion (RTs)
Intentionality (RTs)	1.000	.62***	.571***	.543***	.32**
Goal (RTs)	.62***	1.000	.545***	.601***	.448***
Thinking (RTs)	.571***	.545***	1.000	.555***	.277*
Personality (RTs)	.543**	.601**	.555***	1.000	.444***
Emotion (RTs)	.32**	.448***	.277*	.444***	1.000
Intentionality (YN)	-.110	-.045	-.030	.030	-.050
Goal (YN)	-.200	-.180	-.070	-.070	-.210
Thinking (YN)	-.140	-.220	-.210	-.120	-.050
Personality (YN)	.120	.070	.130	-.030	.060
Emotion (YN)	-.039	-.105	-.130	-.229	-.017
Intentionality (S. RTs)	.382**	.357**	.284*	.282*	.105
Goal (S. RTs)	.456***	.426***	.500***	.462***	.108
Thinking (S. RTs)	.346**	.389**	.423***	.442***	.268*
Praise (S. RTs)	.224	.208	.252	.227	.082
Blame (S. RTs)	.335*	.076	.157	.090	.031
Intentionality (S. YN)	-.062	.025	.034	.163	.154
Goal (Sent. YN)	.006	-.082	.172	.253	-.208
Thinking (Sent. YN)	.116	-.102	.086	.142	.014
Praise (Sent. YN)	.032	-.128	-.043	-.173	-.115
Blame (Sent. YN)	.062	.066	.218	.247	-.036
SAMSI TOTAL	-.147	-.174	-.185	-.255	-.071
SAMSI AFFECT	-.180	-.225	-.255	.302*	-.156
SAMSI FEELINGS	-.170	-.210	-.27*	-.295*	-.272*
SAMSI DESIRE	-.114	-.147	-.120	-.179	.077
SAMSI THINKING	-.065	-.021	-.033	-.040	.060
SAMSI PERSONALITY	.082	.038	.104	.001	.092
Cartoons Scores	-.146	-.283*	-.03	-.074	-.194
Cartoon inferences	-.112	.007	.224	.056	-.176
Mind Eyes	-.109	-.05	-.068	.035	.087
RMET_RTY	.090	.213	.179	.327*	.187
Extroversion	-.137	-.252	-.185	-.175	-.291*
Agreeableness	.089	-.010	-.042	-.151	-.195
Conscientiousness	.108	.105	.027	-.021	.090
Emotional Stability	.286*	.162	.259*	.354**	-.013
Openness to Experience	.080	-.020	-.039	-.019	.147
AQ	-.058	.113	.092	-.041	.236
AQ Social Skills	-.026	.138	.1	.025	.209
AQ Attention Switching	-.108	.029	.005	-.021	.174
AQ Attention to Detail	.009	-.04	.082	-.237	-.116
AQ Communication	-.027	.176	.116	.071	.315*
AQ Imagination	-.040	.050	-.012	.005	.177
Group	-.057	-.225	-.03	-.146	-.287

***** p .001 ** p .01 * p .05**

Table 2: *Correlations for Ease of Inference (Video Stimuli)*

Variable	Intentionality (YN)	Goal (YN)	Thinking (YN)	Personality (YN)	Emotion (YN)
Intentionality (YN)	1.000	.321*	.094	-.045	-.231
Goal (YN)	.321*	1	.268*	.264*	-.095
Thinking (YN)	.094	.268*	1	.435***	.173
Personality (YN)	-.045	.264*	.435***	1	.383**
Emotion (YN)	-.231	-.095	.173	.382**	1.000
Intentionality (Sent. RTs)	-.035	-.136	-.05	-.01	-.225
Goal (Sent. RTs)	.109	.129	-.258	-.072	-.161
Thinking (Sent. RTs)	-.198	-.136	-.063	.103	.139
Praise (Sent. RTs)	-.036	-.041	.157	.133	-.006
Blame (Sent. RTs)	-.158	.083	.163	.27	.139
Intentionality (Sent. YN)	.292*	.191	.037	.071	-.074
Goal (Sent. YN)	.163	.418***	.331**	.241	.078
Thinking (Sent. YN)	.008	.211	.204	.23	.235
Praise (Sent. YN)	.345**	.265*	.169	.163	-.04
Blame (Sent. YN)	-.196	.164	-.086	.106	.043
SAMSI TOTAL	-.136	-.161	.053	.010	.162
SAMSI AFFECT	-.115	-.167	.047	-.017	.209
SAMSI FEELINGS	-.075	-.066	.123	.117	.356**
SAMSI DESIRE	-.121	-.235	-.080	-.197	-.091
SAMSI THINKING	.009	-.020	.017	-.039	-.083
SAMSI PERSONALITY	-.155	-.074	.031	.112	.089
Cartoons Scores	-.015	-.013	-.049	-.060	-.127
Cartoon inferences	.016	.050	-.038	-.058	.046
Mind Eyes	.031	-.118	-.032	.023	.037
RMET_RTY	-.015	-.013	-.049	-.060	.106
Extroversion	.046	.118	.014	-.012	-.213
Agreeableness	.034	-.018	-.130	.025	.000
Conscientiousness	-.084	-.193	-.202	-.014	.163
Emotional Stability	.040	.082	.208	.079	-.155
Openness to Experience	.016	-.086	-.129	-.027	-.065
AQ	-.142	.042	-.046	.066	.217
AQ Social Skills	-.213	.142	.079	.066	.213
AQ Attention Switching	.029	-.059	-.170	-.152	.123
AQ Attention to Detail	-.140	-.031	.052	.078	.038
AQ Communication	.013	-.042	.026	.183	.294*
AQ Imagination	-.158	.125	-.169	.035	.018
Group	-.059	.220	.110	.317*	.150

***** p .001** **** p .01** *** p .05**

Table 3: Correlations for Speed of Inference (Sentence Stimuli RTs)

Variable	Intentionality (S. RTs)	Goal (S. RTs)	Thinking (S. RTs)	Praise (S. RTs)	Blame (S. RTs)
Intentionality (S. RTs)	1.000	.294*	.221	.480***	.137
Goal (S. RTs)	.294*	1.000	.313*	.155	.163
Thinking (S. RTs)	.221	.313*	1.000	.230	-.010
Praise (S. RTs)	.480***	.155	.230	1.000	.248
Blame (S. RTs)	.137	.163	-.010	.248	1.000
Intentionality (S. YN)	.041	.146	-.011	-.205	.177
Goal (S. YN)	.153	.040	.040	.093	.465
Thinking (S. YN)	.101	-.079	-.013	.178	.314
Praise (S. YN)	.073	.141	-.081	.349*	.290
Blame (S. YN)	-.126	.220	.111	.028	-.015
SAMSI TOTAL	-.202	-.257	-.233	-.125	.090
SAMSI AFFECT	-.135	-.364**	-.268	-.102	.056
SAMSI FEELINGS	-.182	-.393*	-.295*	-.080	.157
SAMSI DESIRE	-.006	-.158	-.109	-.073	-.137
SAMSI THINKING	-.196	.001	-.030	-.083	-.036
SAMSI PERSONALITY	-.099	.095	-.042	-.055	.199
Cartoons Scores	-.101	-.027	-.309*	.094	.161
Cartoon inferences	.014	.153	.064	.066	.182
Mind Eyes	.088	.109	.025	.143	.313*
RMET_RTY	-.075	.059	.146	-.104	.180
Extroversion	.048	-.092	-.213	-.165	-.165
Agreeableness	.124	.096	.164	-.295	-.157
Conscientiousness	.1	-.114	.132	.259	.051
Emotional Stability	.416***	.161	.233	.112	.274
Openness to Experience	.076	-.001	.003	.145	-.088
AQ	-.178	.071	.084	.15	-.034
AQ Social Skills	-.051	.044	.074	.15	.005
AQ Attention Switching	-.109	.068	-.004	-.087	-.197
AQ Attention to Detail	-.313*	.068	-.118	.168	.103
AQ Communication	-.073	.029	.157	.237	.035
AQ Imagination	-.069	.033	.166	.064	-.055
Group	-.062	-.015	-.203	.074	-.100

*** p .001 ** p .01 * p .05

Table 4: Correlations for Ease of Inference (Sentence Stimuli)

Variable	Intentionality (S.YN)	Goal (S.YN)	Thinking (S.YN)	Praise (S.YN)	Blame (S.YN)
Intentionality (S. YN)	1.000	.269*	.179	.342**	-.056
Goal (S. YN)	.269*	1.000	.565***	.210	.166
Thinking (S. YN)	.179	.565***	1.000	.153	.124
Praise (S. YN)	.342**	.210	.153	1.000	-.085
Blame (S. YN)	-.056	.166	.124	-.085	1.000
SAMSI TOTAL	-.092	-.100	.015	.123	-.072
SAMSI AFFECT	-.074	-.126	.029	.068	-.144
SAMSI FEELINGS	-.067	-.012	.119	.127	-.100
SAMSI DESIRE	-.052	-.231	-.111	-.046	-.147
SAMSI THINKING	.152	.001	-.031	.073	-.005
SAMSI PERSONALITY	-.286*	.000	.025	.155	.143
Cartoons Scores	.180	.203	.169	.158	.126
Cartoon inferences	.084	.110	.038	.107	.111
Mind Eyes	-.112	.142	.209	.130	.065
RMET_RTY	.010	-.058	-.028	.070	.103
Extroversion	.039	-.092	-.167	.242	-.251
Agreeableness	-.006	-.126	-.085	.040	-.156
Conscientiousness	-.114	-.098	-.107	-.017	-.280*
Emotional Stability	.078	.279*	.167	.175	.024
Openness to Experience	.204	-.163	.001	.154	-.227
AQ	-.026	.008	.109	-.290*	.123
AQ Social Skills	.059	.196	.188	-.198	.173
AQ Attention Switching	-.166	-.129	-.053	-.421***	-.042
AQ Attention to Detail	.034	-.021	.046	.039	-.001
AQ Communication	-.046	-.037	.054	-.205	.080
AQ Imagination	.032	-.009	.114	-.165	.196
Group	.015	.249	.185	-.112	.172

***** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$**

Table 5: *Correlation for the AQ*

Variables	Grp	AQ	AQ Soc.Skills	AQ Attn. Swtch.	AQ Attn Detail	AQ Com.	AQ Imag.
Group	1.000	.202	.196	.008	.235	.157	.065
AQ	.202	1.000	.787***	.675***	.345***	.816***	.666***
AQ Social Skills	.196	.787***	1.000	.423***	.103	.578***	.408***
AQ Attn. Swtch.	.008	.675***	.423***	1.000	-.049	.511***	.326*
AQ Attn. to Detail	.235	.345*	.103	-.049	1.000	.086	.051
AQ Communication	.157	.815***	.578***	.511***	.086	1.000	.478***
AQ Imagination	.065	.666***	.408***	.326*	.051	.478***	1.000
Extroversion	-.148	-.641***	-.662***	-.409***	-.131	-.567***	-.294*
Agreeableness	-.044	-.354**	-.381**	-.115	-.039	-.349**	-.257*
Conscientiousness	.027	-.056	-.102	-.1	.119	-.074	-.007
Emotional Stability	-.046	-.311*	.053	-.410***	-.227	-.211	-.289*
Openness	-.146	-.241	-.147	-.212	.064	-.157	-.363*
SAMSI TOTAL	.122	-.04	-.003	.124	.034	-.04	-.277*
SAMSI AFFECT	.091	-.079	-.044	.058	-.035	-.01	-.258
SAMSI FEELINGS	.083	-.061	.01	.018	.008	-.034	-.228
SAMSI DESIRE	.061	-.069	-.1	.094	-.082	.03	-.186
SAMSI THINKING	.12	.041	.119	.113	.119	-.1	-.138
SAMSI PERSONALITY	.018	.013	-.045	.115	.062	-.002	-.089
Cartoons Scores	.127	.021	.072	-.014	.131	-.14	.024
Cartoon inferences	-.28*	-.039	-.068	.044	.44	-0051	-.095
Mind Eyes	-.127	-.072	-.036	.05	-.124	.029	-.185
RMET_RTY	.07	.138	.062	.087	-.038	.246	.096

*** p .001 ** p .01 * p .05

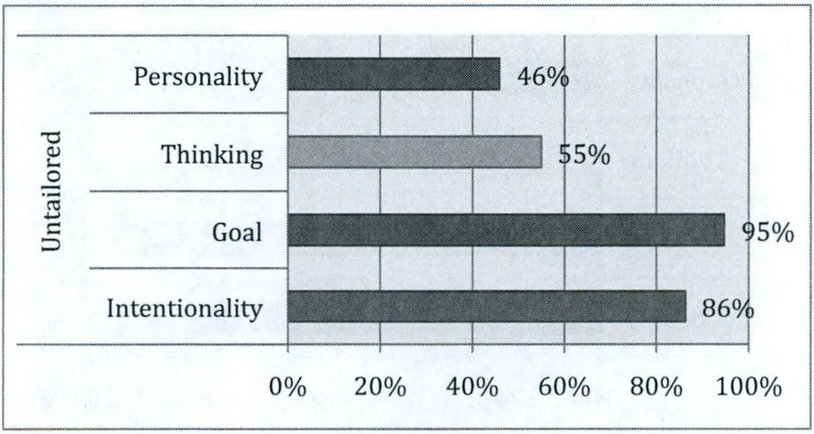


Figure 1. Hierarchy of "Yes" responses to untailored video stimuli.

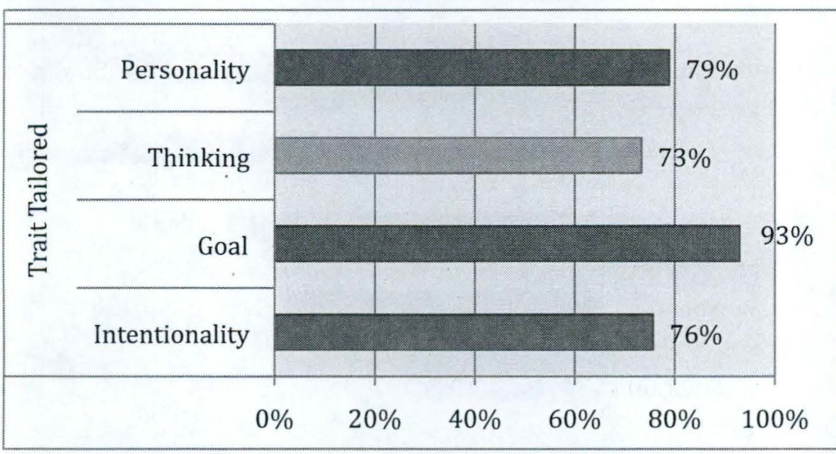


Figure 2. Hierarchy of "Yes" responses to trait-tailored video stimuli.

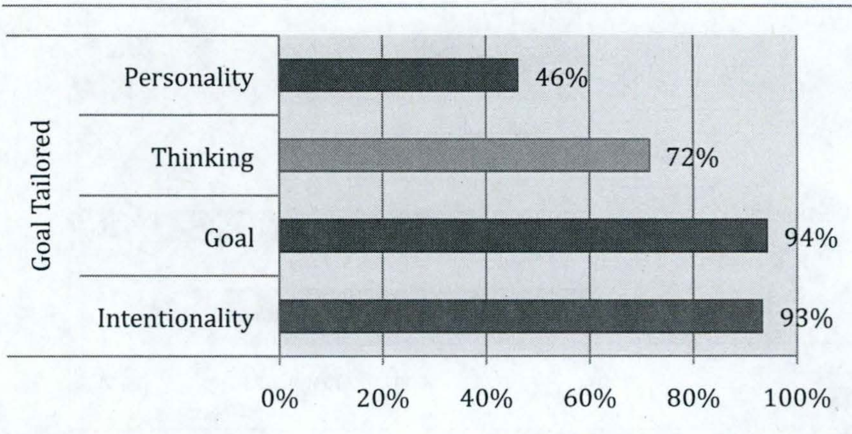


Figure 3. Hierarchy of "Yes" responses to goal-tailored video stimuli.

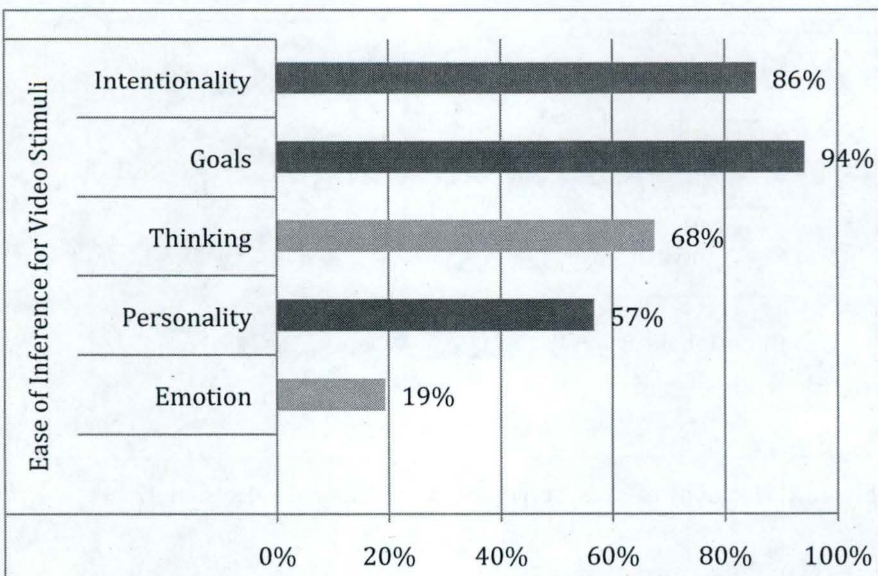


Figure 4. Hierarchy of "Yes" responses overall (video stimuli).

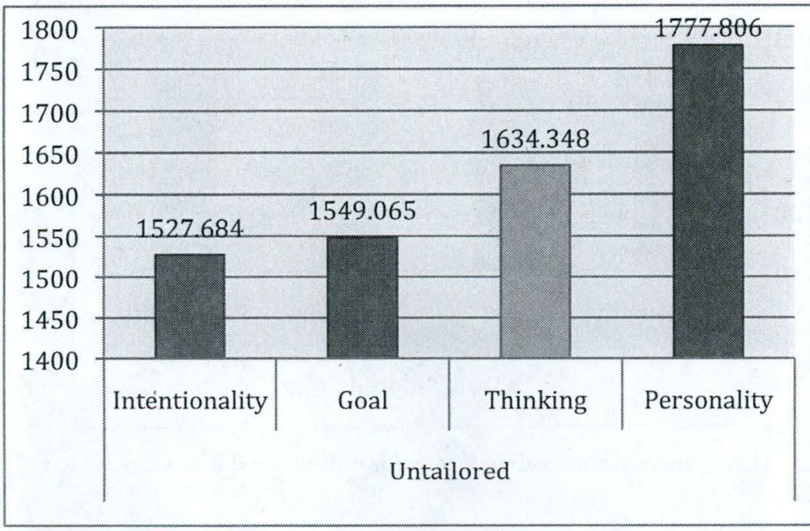


Figure 5. Hierarchy of reaction-time means for untailored behaviors (video stimuli).

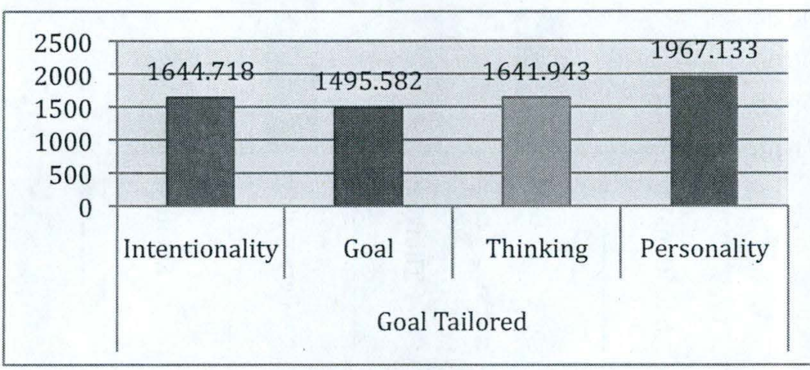


Figure 6. Hierarchy of reaction-time means for goal-tailored behaviors (video stimuli).

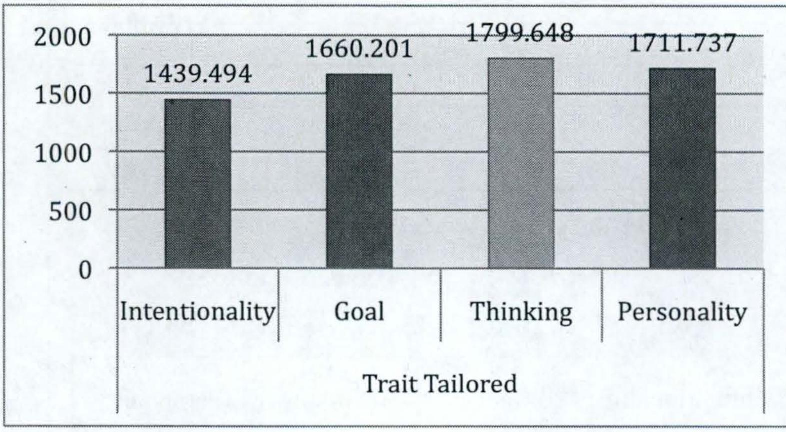


Figure 7. Hierarchy of reaction-time means for trait-tailored behaviors (video stimuli).

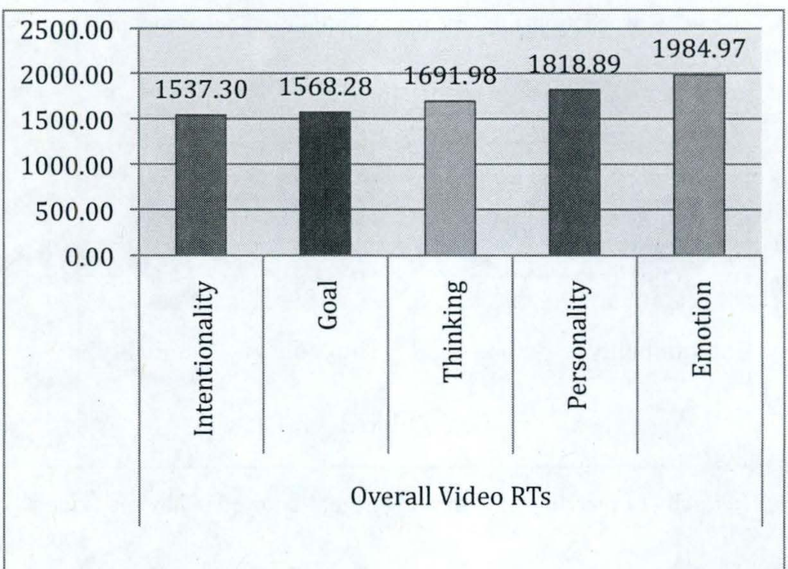


Figure 8. Hierarchy of reaction-time means overall (video stimuli).

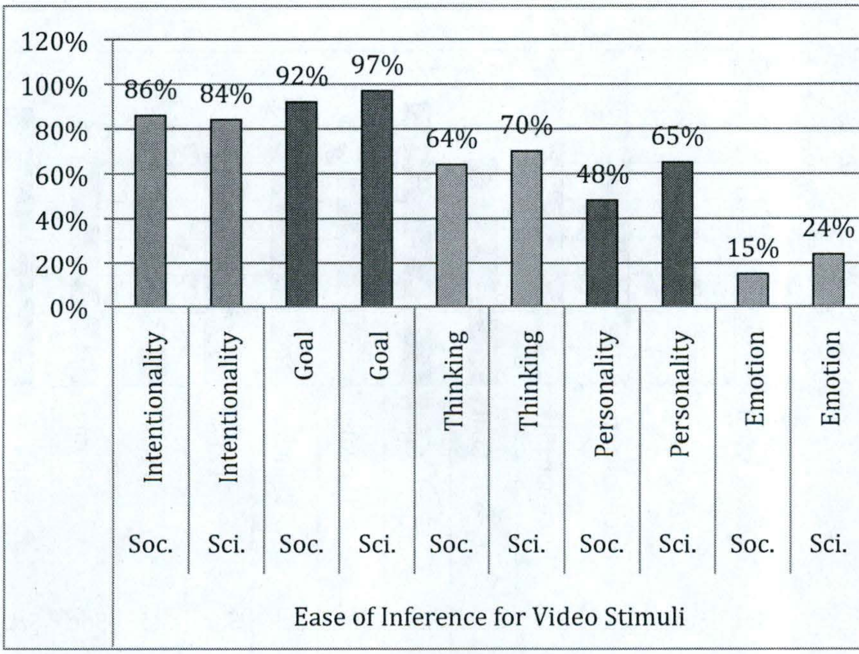


Figure 9. Group comparisons of ease of inference for video

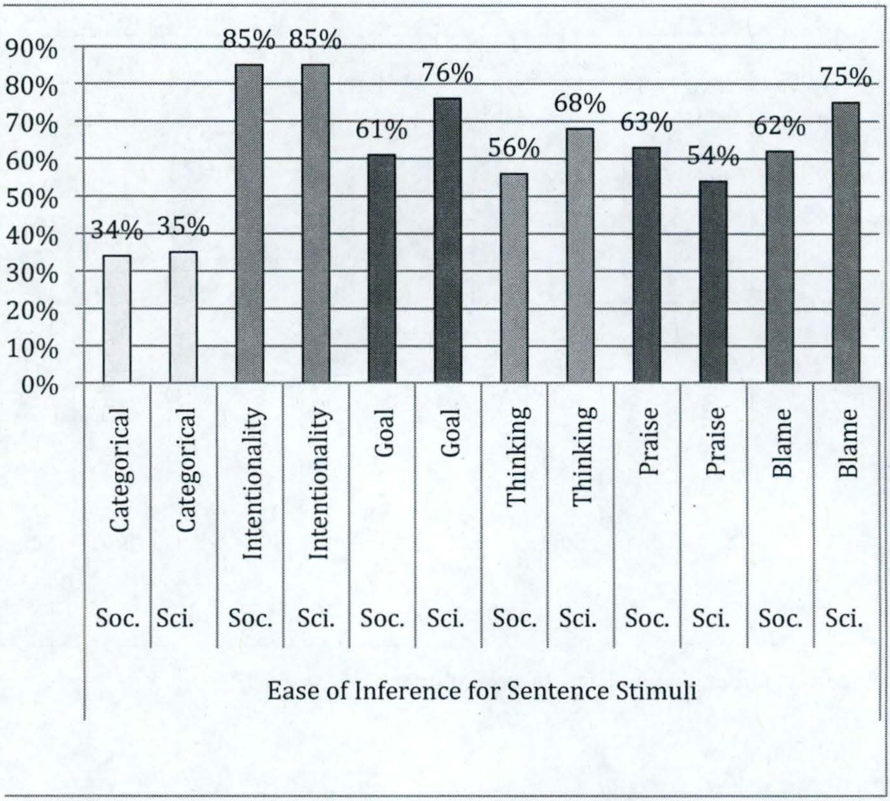


Figure 10. Group times comparisons of ease of inferences for sentence-stimuli.

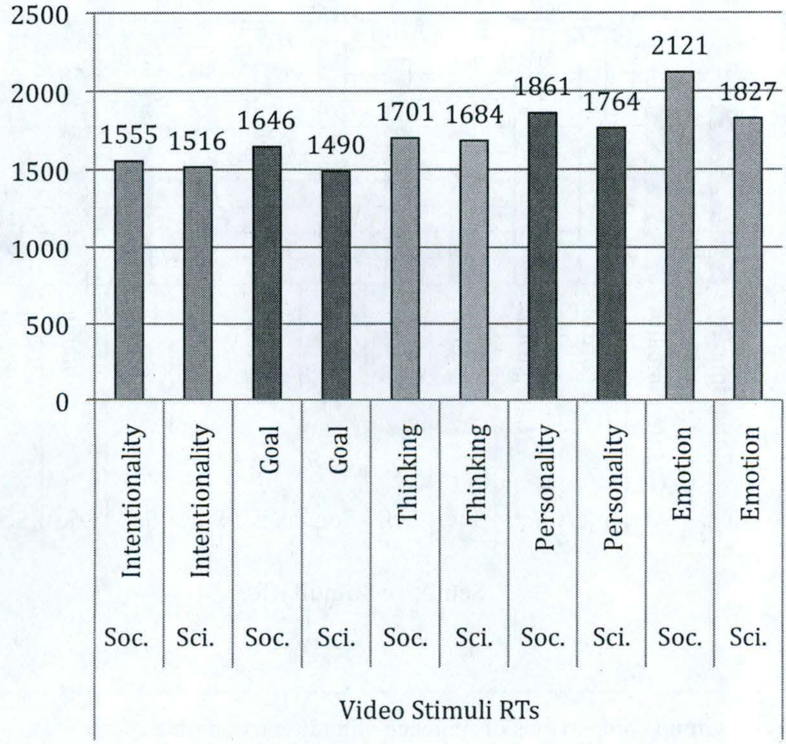


Figure 11. Group comparisons of video-stimuli reaction times.

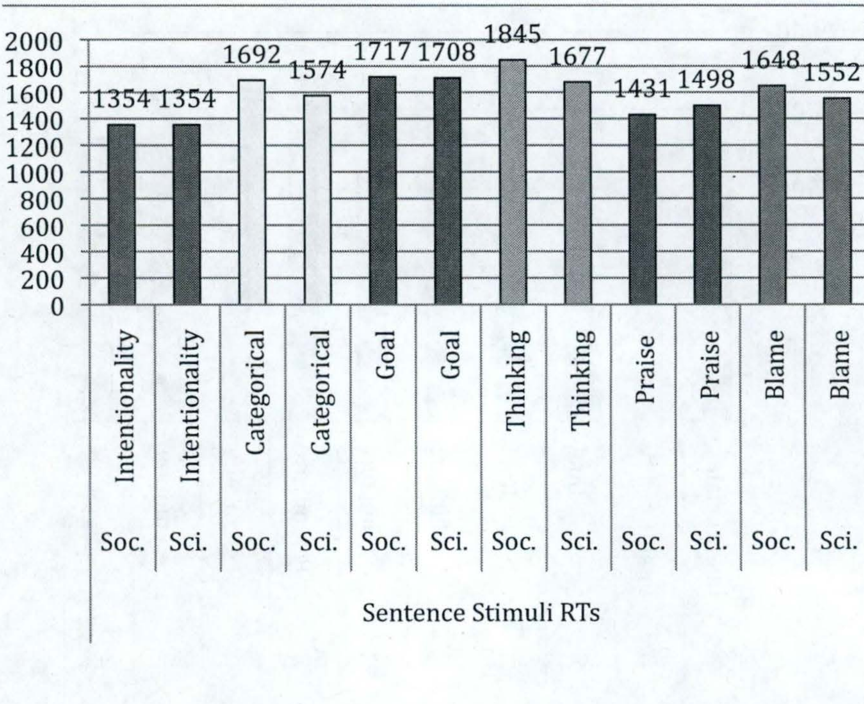
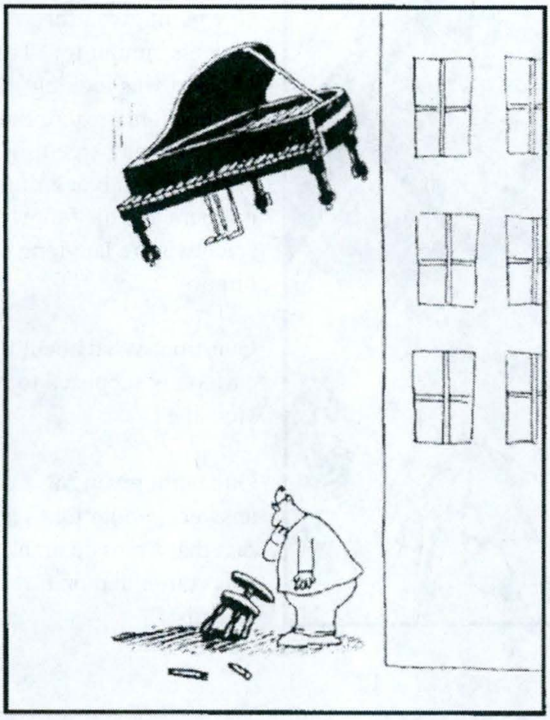


Figure 12. Group comparisons of sentence-stimuli reaction times.

Appendix

Instructions for evaluating cartoon answers.

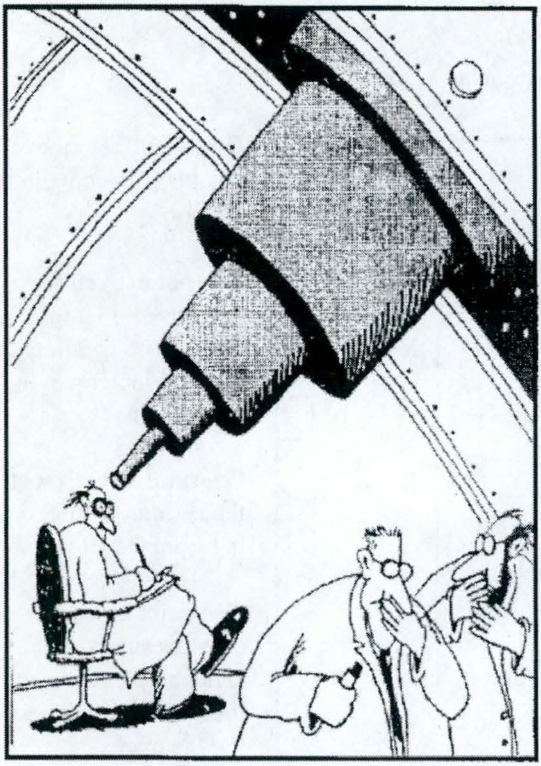


Question: Describe what is happening in the cartoon?

One point given for answers similar to: "The piano is falling on the man looking at the stool."

Question: What about the cartoon is supposed to be amusing?

One point given for answers similar to: "He's so preoccupied by the stool that he doesn't see the piano."

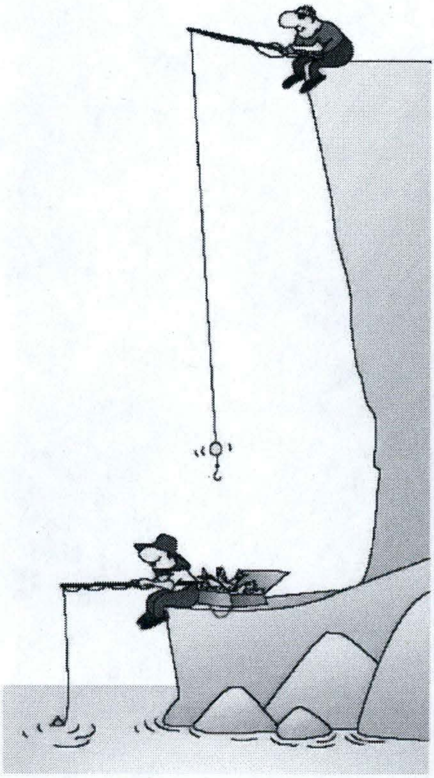


Question: Describe what is happening in the cartoon?

One point given for answers similar to: "The scientist was looking through a microscope and was pranked by getting his eyes with black rings on them and his fellow scientists are laughing at him.

Question: What about the cartoon is supposed to be amusing?

One point given for answers similar to: "The fact that a classic prank was committed on a scientist."



Question: Describe what is happening in the cartoon?

One point given for answers similar to: "Two guys are fishing and one is fishing for the fish the other one already caught."

Question: What about the cartoon is supposed to be amusing?

One point given for answers similar to: "He is fishing for what the other guy already caught."