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Superior Pattern Detectors Efficiently Learn, Activate, Apply, and Update Social Stereotypes

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Superior cognitive abilities are generally associated with positive outcomes such as academic achievement and social mobility. Here, we explore the darker side of cognitive ability, highlighting robust links between pattern detection and stereotyping. Across 6 studies, we find that superior pattern detectors efficiently learn and use stereotypes about social groups. This pattern holds across explicit (Studies 1 and 2), implicit (Studies 2 and 4), and behavioral measures of stereotyping (Study 3). We also find that superior pattern detectors readily update their stereotypes when confronted with new information (Study 5), making them particularly susceptible to counterstereotype training (Study 6). Pattern detection skills therefore equip people to act as naïve empiricists who calibrate their stereotypes to match incoming information. These findings highlight novel effects of individual aptitudes on social–cognitive processes.

Keywords: cognitive ability, pattern detection, social cognition, stereotyping

Human perceivers have a remarkable capacity to divine patterns from noisy data, a skill that distinguishes us from other members of the animal kingdom (Kurzweil, 2012). Indeed, pattern recognition is critical for our ability to learn languages (Keil, 1989; Markman, 1990), recognize faces (Samal & Iyengar, 1992), sort novel stimuli into categories (Rosch, 1973), and detect emotional states in ourselves and others (Picard, Vyzas, & Healey, 2001). Given its vast implications for human experience, it is unsurprising that pattern recognition is highly correlated with other faculties (DeRue, Ashford, & Myers, 2012; Gustafsson, 1984; Salthouse, Pink, & Tucker-Drob, 2008; Shelton, Elliott, Hill, Calamia, & Gouvier, 2009), including general intelligence (Jensen, 1980; Spearman, 1946; Vernon & Parry, 1949).

As with other aptitudes, pattern detection ability varies considerably across persons (Bors & Stokes, 1998). In many cases, superior pattern detectors fare well (Gottfredson, 1997). In some cases, however, pattern detection can lead to detrimental ends. For example, an overactive disgust response that generalizes previously negative encounters to novel stimuli is implicated in obsessive–compulsive disorder (Olatunji, Cisler, McKay, & Phillips, 2010). Pattern detection can lead people to falsely recognize symptoms consistent with an illness after diagnosis (Arkes & Harkness, 1980). Precise detection of small variations among

members of similar categories may contribute to autism symptomatology (Van de Cruys et al., 2014). Another possibility, which has yet to be fully explored, is that pattern recognition may have negative implications for intergroup processes such as stereotyping. After all, stereotypes are behavioral patterns that are learned about a group and later generalized to individual members of that group. The present research explores this possibility, testing whether superior pattern detectors stereotype more readily than others.

Pattern Detection and Intelligence

Few topics have garnered as much attention in psychological research as human cognitive ability (Deary & Smith, 2004), defined as the capacity to obtain, store, revise, and use information to support everyday activity (Gottfredson, 1997). Although the effects are vast, researchers have identified a small set core aptitudes that explain a great deal of the variability in cognitive ability across persons (Carroll, 1997; Cattell, 1963; Gustafsson, 1984; Horn & Cattell, 1966; Spearman, 1927; Toga & Thompson, 2005). Pattern detection is one such aptitude that is shared across most contemporary models of human intelligence (Mackintosh & Mackintosh, 2011). Indeed, pattern detection ability is highly correlated with measures of both general intelligence and fluid intelligence (Alderton & Larson, 1990; Bors & Stokes, 1998; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Fry & Hale, 2000). Measures of pattern detection ability are also included in all major intelligence test batteries (Cattell, 1949; Thorndike, Hagen, & Sattler, 1986; Wechsler, 2003, 2014). One particular measure of pattern detection—Raven's Advanced Progressive Matrices (Raven, Raven, & Court, 2004)—has been called an ideal measure of human intelligence for its ability to predict a wide variety of other aptitudes (Carpenter, Just, & Shell, 1990; DeShon, Chan, & Weissbein, 1995).

Intelligence and pattern recognition have garnered substantial research attention because they predict a number of important life outcomes (Gottfredson, 1997). For example, people with superior

cognitive abilities tend to experience greater academic achievement, job performance, social mobility, and physical well-being than others (Batty, Deary, & Gottfredson, 2007; Deary, Strand, Smith, & Fernandes, 2007; Strenze, 2007). There are also cases in which superior cognitive abilities can be harmful (Olatunji et al., 2010; Van de Cruys et al., 2014), though most work on the negative implications of cognitive ability has focused on psychopathologies (e.g., obsessive–compulsive disorder). Below, we turn to a more common domain of human experience that may be associated with cognitive ability: intergroup relations.

General Links Between Cognitive Ability and Intergroup Relations

Intergroup relations describe the processes through which people represent, evaluate, and interact with those belonging to different social groups (Messick & Mackie, 1989). Since the 1980s, researchers have focused on cognitive mechanisms underlying intergroup relations (Macrae & Bodenhausen, 2000), with hundreds of studies revealing how basic information-processing systems guide social interaction (Fiske & Taylor, 2013). Given the well-documented links between cognition and sociality, it seems reasonable to expect that cognitive ability might play a role in intergroup relations.

Existing research has offered preliminary insight into the association between cognitive ability and intergroup relations, though much of this work has examined intergroup relations indirectly via self-reported policy attitudes. For example, early studies revealed that people with superior cognitive abilities were less likely to subscribe to authoritarian beliefs and more likely to support liberal social policies than those with inferior cognitive abilities (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950; Kutner & Gordon, 1964; McCourt, Bouchard, Lykken, Tellegen, & Keyes, 1999; Sanders, Lubinski, & Benbow, 1995; Scarr, Webber, Weinberg, & Wittig, 1981). The dominant explanation for these trends is the *enlightenment perspective*, which proposes that highly intelligent people are able to integrate complex information into their attitudes and ultimately form opinions that support others who differ from themselves along important social dimensions (McCourt et al., 1999; Scarr et al., 1981). In contrast, people with lower cognitive ability are thought to prefer conservative ideologies that maintain the status quo to protect their own interests (Heaven, Ciarrochi, & Leeson, 2011; Stankov, 2009).

A smaller body of work has examined links between cognitive ability and intergroup attitudes directly, though the findings are mixed. Some studies have documented negative associations between cognitive ability and measures of dehumanization, ethnocentrism, and intolerance toward outgroups (Deary, Batty, & Gale, 2008; Gough & Bradley, 1993; Van Hiel, Onraet, & De Pauw, 2010). In fact, a recent meta-analysis revealed a modest but reliable negative correlation between cognitive ability and prejudice ($r = -.19$; Onraet et al., 2015). However, other studies have reported no association between cognitive ability and intergroup bias (Altemeyer, 1988; Glaser, 2001; McCann, Short, & Stewin, 1986; Rokeach, 1951; Schaefer, 1996; Wright & Phillips, 1979), or even a positive association between cognitive ability and intergroup bias (Katz, 1990; Steininger & Colsher, 1979; Taylor & Dunnette, 1974; Wodtke, 2016). The latter findings are consistent with predictions from the *ideological refinement perspective*,

which proposes that groups attempt to legitimize their standing within the social hierarchy. According to this perspective, White Americans have developed stereotypes that Black Americans are unintelligent to legitimize discriminatory practices that have consistently kept Blacks at the bottom of the social hierarchy. Because of the rationalization required to maintain and propagate stereotypes, one specific prediction of the ideological refinement perspective is that people with superior cognitive abilities are especially likely to express intergroup biases (Jackman, 1978; Jackman & Muha, 1984; Wodtke, 2013, 2016).

Thus, existing research on the links between cognitive ability and intergroup bias has yielded mixed results. Methodological limitations may be partly to blame, as many studies have relied on self-reported attitudes. Explicit measures are problematic because intelligent people may be aware of contemporary norms against prejudice and have the resources necessary to respond in socially desirable ways (Wodtke, 2016). It also bears noting that most of the relevant studies utilized cross-sectional samples and correlational designs, precluding inferences about the causal relationship between cognitive ability and intergroup relations (Dhont & Hodson, 2014). Studies that employ experimental techniques, implicit measures, and behavioral outcomes are critical to disentangling the impact of cognitive ability on intergroup bias.

Specific Links Between Cognitive Ability and Stereotyping

As described above, previous studies linking cognitive ability to intergroup relations have covered a wide range of outcomes. For example, dependent variables have ranged from political orientation to endorsement of authoritarian beliefs, support for nontraditional marriage, explicit racial prejudice, endorsement of nondiscrimination policies, and subtle dehumanization of outgroups. Thus, another explanation for the inconsistencies in this literature may be that the question at hand—"Are cognitive abilities associated with intergroup relations?"—is too broad. Intergroup relations involve distinct psychological processes, and it seems unlikely that cognitive ability will have consistent effects across the board. A more nuanced consideration of how specific cognitive abilities are associated with specific intergroup processes would provide greater clarity.

One intergroup process that to our knowledge has not been linked to cognitive ability is stereotyping, or the generalization of beliefs about the traits of a social group to individual members of the group (Lippmann, 1922). By enabling perceivers to quickly form an impression of others based on the groups to which they belong, stereotypes are thought to simplify the task of social perception (McCauley, Stitt, & Segal, 1980). As such, stereotypes are seen as common and even necessary heuristics that people use to ease the demands of social life (Fiske, 2000).

Note that we are drawing an important distinction between stereotypes, which are characterized as cognitive knowledge structures, and prejudices, which are characterized as affective feelings toward a group. While numerous studies have tested links between cognitive ability and prejudice (see Onraet et al., 2015), none have done so for stereotyping. This omission seems curious because stereotyping is a form of pattern recognition that involves extracting behavioral trends from a group and applying them to individual members of that group. Moreover, the activation of stereotypes can

occur through computational processes that overlap with nonsocial associations (Freeman & Ambady, 2011), highlighting stereotypes as a byproduct of more general cognitive processes. It therefore seems possible that superior pattern detectors are especially adept at acquiring stereotypes.

Of course, just because people can extract stereotypes about groups does not necessarily mean they will use those stereotypes to evaluate others. Social psychologists have long distinguished between stereotype activation (i.e., accessibility of stereotypical knowledge) and stereotype application (i.e., use of stereotypical knowledge when evaluating others; Kunda & Spencer, 2003; Kundra & Sinclair, 1999). Stereotype activation is thought to be largely unavoidable, as even members of negatively stereotyped groups activate stereotypical knowledge about their group (Devine, 1989). Stereotype application is subject to conscious control: People who are motivated by egalitarian ideals (Devine, Monteith, Zuwerink, & Elliot, 1991; Plant & Devine, 1998) and have cognitive resources necessary to overcome heuristic information processing (Gilbert & Hixon, 1991) can successfully inhibit stereotypes. This distinction gives rise to several possibilities about the association between pattern detection ability and stereotyping. First, people with superior cognitive abilities may neither activate nor apply stereotypes. This proposal is consistent with the enlightenment perspective described above, which predicts a negative association between cognitive ability and intergroup bias (McCourt et al., 1999; Scarr et al., 1981). Second, people with superior cognitive abilities may active stereotypical knowledge, but inhibit that knowledge before applying it to others. This proposal is consistent with the idea that cognitive resources are necessary to avoid stereotyping (Gilbert & Hixon, 1991); people with higher cognitive ability have access to more resources, resulting in low rates of stereotype application. Third, people with superior cognitive abilities may readily activate stereotypes and apply stereotypes. This proposal is consistent with predictions from the ideological refinement perspective, which hypothesize that highly intelligent people are more likely to express intergroup biases than are less intelligent people (Glaser, 2001; Jackman & Muha, 1984; Wodtke, 2016). New studies are necessary to adjudicate between these predictions about the association between cognitive ability and stereotyping.

The Current Research

In summary, although cognitive processes have featured prominently in contemporary studies of intergroup relations, researchers have yet to examine links between cognitive ability and stereotyping (Dhont & Hodson, 2014; Hodson & Busseri, 2012). The current research aims to fill this gap by testing associations between a core aspect of cognitive ability—pattern recognition—and processes involved in stereotyping. Studies 1–5 provide a pure test of our hypotheses using novel stereotypes about fictional groups, which controls for between-person variability in factors such as stereotype exposure, stereotype endorsement, political affiliation, and motivation to control bias. Study 6 extends our findings to existing stereotypes with real-world implications. The studies employ diverse methodologies to provide a rich understanding of how cognitive abilities predict the learning, activation, application, and updating of social stereotypes.

Study 1

Stereotypes are generalizations about the traits of social groups that are applied to individual members of those groups. To make such generalizations, people must detect a reliable pattern among members of a particular group and must categorize an individual as belonging to that group. Both processes rely on pattern detection ability. These findings suggest that superior pattern detectors may be well equipped to learn and apply stereotypes. Study 1 tested these hypotheses in a novel groups paradigm that enabled us to examine learning as well as application of stereotypical knowledge as a function of pattern detection ability.

Method

Participants. Two hundred seventy-one Mechanical Turk users ($M_{age} = 36.71$ years, $SD_{age} = 11.54$ years, 46% male, 79% White) completed the study. Studies have shown that Mechanical Turk participants follow instructions at least as closely as those from traditional subject pools, providing high-quality data that replicate classic effects from social and cognitive psychology (Paolacci, Chandler, & Ipeirotis, 2010; Paolacci & Chandler, 2014). Also, Mechanical Turk participants are more diverse than most undergraduate psychology pools (Buhrmester, Kwang, & Gosling, 2011). This was especially important for the current studies, given our focus on cognitive ability. Sampling university undergraduates could have restricted the range of cognitive ability in our samples, reducing statistical power to detect effects. Mechanical Turk provided an efficient method for collecting high-quality data from a large sample of people with varying levels of cognitive ability.

We could not locate relevant studies on which to base a power analysis, so we aimed to collect a large sample ($N = 275$) that provided sufficient power to detect relatively small effects. Specifically, 258 participants were required for 90% power to detect a correlation of 0.2 at $\alpha = .05$.

Procedure. Mechanical Turk users completed two ostensibly unrelated tasks in counterbalanced block order. In the stereotyping task, they assumed the role of an intergalactic explorer encountering an alien species for the first time. Participants were to learn about the aliens' behaviors to report home about this new species. The task began with a learning phase in which participants saw images of 36 aliens paired with unique behaviors. Half of the aliens were paired with friendly behaviors (e.g., gave another alien a box of chocolates) and half of the aliens were paired with unfriendly behaviors (e.g., stole candy from a baby alien; Table 1). The aliens themselves varied along four dimensions—color (*yellow, red, blue*), shape (*round, square, oval*), eye size (*large, medium, small*), and ear type (*none, straight, curved;* Figure 1). Most of these features were equally associated with friendly and unfriendly behaviors, but 80% of the blue aliens were paired with unfriendly behaviors and 80% of the yellow aliens were paired with friendly behaviors. Participants viewed the alien behaviors in random order at their own pace, pressing the spacebar when they were ready to proceed to the next pairing. After viewing all 36 alien/behavior pairings, participants completed an identification test. They were presented a behavioral statement from the learning phase alongside a visual line-up of six aliens (two blue, two red, two yellow) and asked to identify which alien had performed the behavior in question (see Figure 2). Participants responded to a

Table 1
Friendly and Unfriendly Behaviors Used in Stereotype Learning Phase

Friendly behaviors	Unfriendly behaviors
Gave another alien a bouquet of flowers.	Spat in another alien's face.
Helped an elderly alien across the street.	Stole another alien's food.
Lifted a heavy box for an injured alien.	Spray painted curse words on another alien's fence.
Sent flowers to a sick alien.	Shouted at a young alien for no good reason.
Mowed an elderly alien's lawn free of charge.	Made fun of another alien who tripped and fell.
Donated clothes to a shelter for homeless aliens.	Intentionally frightened another alien's young brother.
Threw a party to celebrate a lonely alien's birthday.	Tore up a neighbor alien's newly planted flowers.
Offered to take care of another alien's pet.	Threw a rock through another alien's window.
Taught another alien to read and write.	Won several prizes after cheating in a lottery.
Put on a play for elderly aliens in a retirement home.	Teased and belittled a young alien.
Worked at a soup kitchen for homeless aliens.	Punched another alien in the face for no good reason.
Donated to a charity for poor aliens.	Spread false rumors about other aliens.
Tended to a sick alien.	Stole candy from an alien baby.
Destroyed a public painting that other aliens loved.	Spent many hours comforting a sad alien.
Started a free class to teach young aliens to swim.	Tripped other aliens by smearing oil on a footpath.
Helped an alien who had fallen.	Threw sand in another alien's face for no good reason.
Gave another alien a box of chocolates.	Laughed and jeered at a homeless alien.
Cooked several meals for an alien who was sick.	Refused to help an elderly alien across the street.

total of 12 line-ups, with 6 trials assessing friendly behaviors and 6 trials assessing unfriendly behaviors.

In a counterbalanced block, participants completed a test of pattern detection ability. The items were drawn from Raven's Advanced Progressive Matrices (Raven et al., 2004), a well-validated measure of pattern detection ability that is highly correlated with both general and fluid intelligence (Carpenter et al., 1990; DeShon et al., 1995). In each test item, participants were presented with a 3 × 3 matrix containing letters, numbers, or abstract symbols. Each matrix progressed in a systematic fashion—for example, numbers doubling from one cell to the next (e.g., 2 – 4 – 8 – 16 – 32 – 64 – 128 – 256). The final cell in each matrix was left blank, such that participants had to discern the pattern to fill in the missing space with one of several multiple-choice answers. Participants completed 19 items in total, including 9 symbol matrices, 5 letter matrices, and 5 number matrices. After completing both tasks, participants provided demographic information and were debriefed about the study aims.

Results and Discussion

The learning phase was structured such that 80% of the blue aliens were paired with unfriendly behaviors and 80% of the yellow aliens were paired with friendly behaviors. Each item in the line-up identification test included two aliens from each color category (two red, two blue, two yellow). We measured stereotyping as the extent to which participants committed identification errors that were consistent with the color stereotypes presented in the learning phase. Specifically, we coded responses to the alien identification task as correct (i.e., correctly ascribing a given behavior to the appropriate alien; $M = 3.08$, $SD = 1.79$), stereotype-consistent error (i.e., mistakenly ascribing a behavior to an alien of the same color as the correct alien; $M = 2.12$, $SD = 1.39$), or miscellaneous error (i.e., mistakenly ascribing a behavior to an alien of a different color as the correct alien; $M = 6.81$, $SD = 2.14$). We were primarily interested in the stereotype-consistent errors, which captured participants' tendency to generalize traits learned about a group (e.g., unfriendly behavior of blue aliens) to an individual member of that group (e.g., a blue alien). To assess pattern detection ability, we calculated each participant's proportion of correct responses to the 19 matrix items ($M = 0.38$, $SD = 0.17$).

We hypothesized that participants with superior pattern detection abilities would efficiently learn social stereotypes, committing more stereotype-consistent errors in the alien identification task than participants with inferior pattern detection abilities. We tested our hypothesis by separately regressing the number of each outcome participants achieved in the identification task (*correct re-*
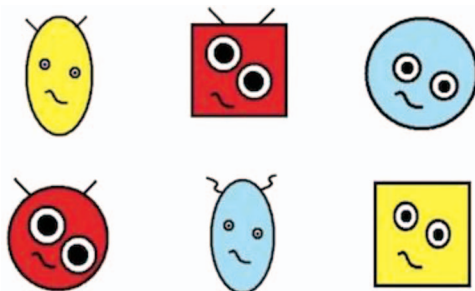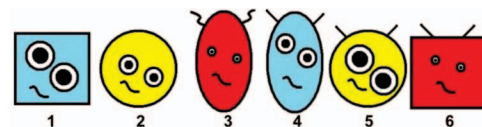

Figure 1. Sample alien targets differing in color (*red, yellow, blue*), shape (*oval, circle, square*), eye size (*small, medium, large*), and ears (*none, straight, curly*). See the online article for the color version of this figure.

Punched another alien in the face for no reason.

Figure 2. Sample line-up identification item in which participants had to select the alien who had committed the depicted behavior. See the online article for the color version of this figure.

sponse, stereotype-consistent error, miscellaneous error) onto pattern detection ability. Relative to inferior pattern detectors, superior pattern detectors responded to more questions correctly, $B = 1.33$, $SE = 0.62$, $t = 2.15$, $p = .033$, $R^2 = 0.02$, and made fewer miscellaneous errors, $B = -2.50$, $SE = 0.73$, $t = -3.42$, $p = .001$, $R^2 = 0.04$. Consistent with predictions, however, superior pattern detectors also made more stereotype-consistent errors, $B = 1.17$, $SE = 0.48$, $t = 2.46$, $p = .015$, $R^2 = 0.02$. In follow-up analyses, we examined the proportion of stereotype-consistent errors to total errors as a function of pattern detection ability. Here again, superior pattern detectors were significantly more likely to make stereotype-consistent errors than were inferior pattern detectors, $B = 0.17$, $SE = 0.06$, $t = 2.99$, $p = .003$, $R^2 = 0.03$.[1]

Study 1 revealed an association between cognitive ability and stereotyping. Superior pattern detectors achieved relatively high accuracy when recalling the behaviors of novel aliens. On trials resulting in misidentifications, however, superior pattern detectors tended to err in a stereotype-consistent manner. That is, superior pattern detectors tended to ascribe friendly behaviors to the wrong yellow alien and unfriendly behaviors to the wrong blue alien. Pattern detection ability was therefore positively associated with the learning and application of stereotypical knowledge about novel groups.

Study 2

Study 1 provided preliminary evidence for an association between pattern detection and stereotyping, but it could not differentiate between the distinct processes of stereotype activation and stereotype application. Stereotype activation is thought to be largely automatic, indicating accessibility of stereotypical knowledge regardless of one's personal endorsement of that knowledge (Brewer, 1988; Perdue & Gurtman, 1990; Pratto & Bargh, 1991). Stereotype application is thought to reflect more controlled processing that results in the utilization of stereotypical knowledge to evaluate an individual group member (Devine, 1989). Because application is subject to effortful cognitive processing, people who are motivated by egalitarian ideals and who have sufficient cognitive resources can avoid applying stereotypes even when they have been activated (Devine et al., 1991; Gilbert & Hixon, 1991).

These distinctions raise additional questions about the links between pattern detection and stereotyping. To the extent that superior pattern detectors efficiently learn behavioral patterns about social groups, they may be particularly likely to active stereotypes upon encountering individual group members. Predictions about pattern detection and stereotype application are less clear. On the one hand, superior pattern detectors might not apply stereotypes because they have the cognitive resources necessary to overcome heuristic processing. On the other hand, superior pattern detectors might apply stereotypes readily because their cognitive system is highly tuned to patterns, of which stereotypes are one example. Study 2 tested these possibilities by comparing associations between pattern detection ability, stereotype activation, and stereotype application for novel categories.

Method

Participants. Two hundred forty-six Mechanical Turk users (50% male, 78% White, $M_{age} = 35.13$ years, $SD_{age} = 10.88$ years) completed the study.

Procedure. Participants completed a series of ostensibly unrelated tasks described as a pilot test for future research. First, participants completed the learning phase described in Study 1. They viewed 36 alien/behavior pairings in random order, with 80% of the blue aliens performing unfriendly behaviors and 80% of the yellow aliens performing friendly behaviors. Next, they completed two additional tasks in counterbalanced block order.

One of these blocks involved a lexical-decision task to assess stereotype activation. On each trial, participants saw a fixation cross (500 ms) followed by one of three color splashes (*red, yellow, blue*; 250 ms), an inter stimulus interval (200 ms), and a letter string. They had to decide via button press whether the letter string represented a real word or not. Critically, some of the letter strings were stereotypical of yellow aliens (*friendly, kind, nice, generous, warm*), some were stereotypical of blue aliens (mean, *cruel, hateful, violent, unfriendly*), some were nonstereotypical (*alert, witty, artistic, gullible, elderly*), and some were nonwords. The nonwords were random combinations of the letters in each of the stereotypical and nonstereotypical words, ensuring the targets were of equal length (*drflynei, dikn, cnie, oresngue, rwma, iyunnedlfr, aenm, euclr, auehlft, envtloi*). Participants completed 75 lexical decision trials total, with color splashes and letter strings paired randomly throughout.

The other block involved an explicit rating task to assess stereotype application. Participants viewed a series of 15 aliens (5 red, 5 blue, 5 yellow) in random order and evaluated each one along six dimensions—two stereotypically blue traits (*mean, cruel*), two stereotypically yellow traits (*friendly, kind*), and two nonstereotypical traits (*witty, artistic*)—using 9-point rating scales (1 = *not at all* to 9 = *extremely*). Participants received as much time as necessary to render each judgment.

Upon finishing both stereotyping tasks, participants completed the 19 matrix problems from Study 1 as a measure of pattern detection ability. Finally, they provided demographic information and were debriefed about the study aims.

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[1] Because these data were collected online for a relatively small incentive, participants had little motivation to perform well. A reviewer pointed out that participants who were unmotivated may have performed poorly on both the line-up test and the pattern detection test, raising the possibility that our findings may have been driven by motivation rather than cognitive ability. To test this hypothesis, we ran a follow-up study ($N = 234$ Mechanical Turk users; 61% female; 72% White; $M_{age} = 36.52$ years) that included an attention check in the line-up test ("Select option 4 from the list below") and a three-item scale tapping self-reported motivation to perform well (e.g., "I tried my very best to answer the pattern completion questions correctly;" $\alpha = .82$). We replicated our original finding, such that the proportion of stereotype-consistent errors was higher among superior pattern detectors compared with inferior pattern detectors, $B = 0.12$, $SE = 0.06$, $t = 2.23$, $p = .027$, $R^2 = 0.02$. Only 18 participants (7.7% of the sample) failed the attention check, and the association between pattern detection and stereotype-consistent errors remained significant when excluding these participants, $B = 0.12$, $SE = 0.06$, $t = 2.01$, $p = .046$, $R^2 = 0.02$. The interaction of pattern detection ability and self-reported motivation did not significantly predict the proportion of stereotype-consistent errors, $B = 0.08$, $SE = 0.08$, $t = 1.02$, $p = .309$, $R^2 = 0.03$. Thus, the findings reported in Study 1 do not appear to be an artifact of low motivation. We return to these points in the General Discussion.

Results and Discussion

We calculated the proportion of correct matrix responses for each participant as a measure of pattern detection ability ($M = 0.33$, $SD = 0.19$). We operationalized stereotype activation in the lexical-decision task as response facilitation when recognizing stereotypical words relative to nonstereotypical words following a relevant prime (e.g., faster response to the target word *friendly* following a blue prime compared with a red prime). Consistent with prior research (Wittenbrink, Judd, & Park, 2001), we excluded lexical decision responses that resulted in incorrect word/nonword decisions (6.07% of trials) as well as those with latencies less than 150 ms (1.44% of trials) or greater than 3000 ms (0.86% of trials). As is common with reaction time (RT) measures, the distribution of response latencies was positively skewed, so we applied a log transformation to satisfy statistical assumptions. We then subtracted response latencies for word/nonword decisions on trials that presented stereotype-irrelevant pairings (e.g., blue color followed by the target word *artistic*) from response latencies for word/nonword decisions on trials that presented stereotype-consistent pairings (e.g., blue color followed by the target word *friendly*). We aggregated the resulting values within participant as a measure of the extent to which each person activated stereotypes related to alien color, such that higher values indicated greater stereotype activation.

We operationalized stereotype application as higher explicit ratings for stereotype-consistent traits relative to stereotype-irrelevant traits for each alien (e.g., rating blue aliens as being more *friendly* than *artistic*). Specifically, we subtracted average ratings for the stereotype-irrelevant traits for each alien from average ratings for the stereotype-consistent traits for each alien. We aggregated the resulting values within participant as a measure of the extent to which each person explicitly applied stereotypes related to alien color, such that higher values indicated greater stereotype application.

Stereotype activation. We began by exploring outcomes related to stereotype activation, operationalized as response facilitation for stereotype-consistent compared with stereotype-irrelevant

words in the lexical-decision task. We first tested whether participants showed evidence of stereotype activation overall by subjecting average stereotype activation to a one-sample *t* test against a null value of 0. Mean levels of stereotype activation were significantly greater than 0, $t(198) = 150.79$, $p < .001$, $d = 10.66$, such that participants responded about 30 ms faster ($M = 26.77$ ms, $SD = 112.28$ ms) for stereotypical color/word pairings relative to nonstereotypical color/word pairings. This finding serves as a manipulation check indicating that participants learned the association between alien color and friendly traits.

We then turned to our focal analysis regarding the association between pattern detection and stereotype activation. Specifically, we regressed each participant's stereotype activation score onto their pattern detection score. As expected, superior pattern detectors showed greater stereotype activation than did inferior pattern detectors, $B = 0.60$, $SE = 0.24$, $t = 2.50$, $p = .013$, $R^2 = 0.03$ (Figure 3a).

Stereotype application. We also explored stereotype application, operationalized as higher explicit ratings on traits that were stereotype-consistent compared with stereotype-inconsistent for a given alien. We first tested whether the sample showed evidence of stereotype application overall by subjecting average scores to a one-sample *t* test against a null value of 0. Mean levels of stereotype application were significantly greater than 0, $t(218) = 3.04$, $p = .003$, $d = 0.20$, such that participants rated aliens about 0.23 points higher ($SD = 1.13$) on stereotypical traits relative to nonstereotypical traits. This finding serves as a manipulation check indicating that participants learned the association between color and friendliness for alien targets.

We then turned to our focal analysis regarding the association between pattern detection and stereotype application. Specifically, we regressed each participant's stereotype application score onto their pattern detection score. Compared with inferior pattern detectors, superior pattern detectors showed greater stereotype application, $B = 1.02$, $SE = 0.44$, $t = 2.31$, $p = .022$, $R^2 = 0.03$ (Figure 3b).
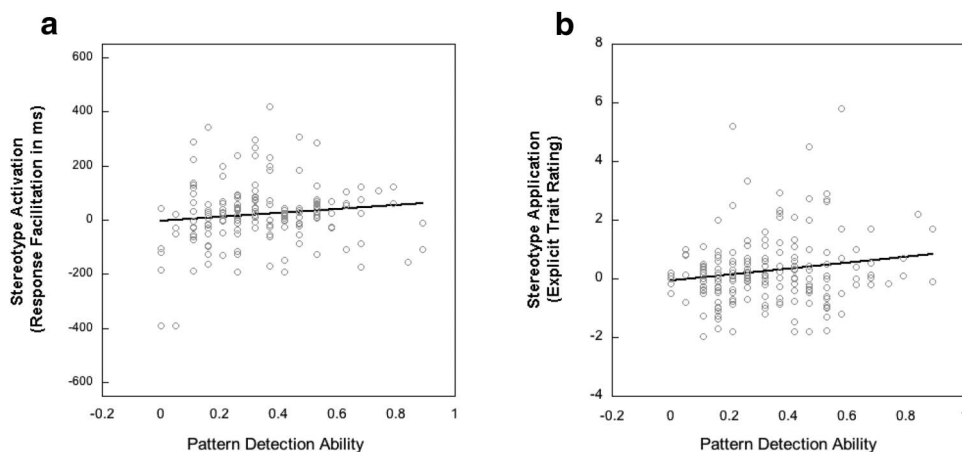

Figure 3. Implicit stereotype activation (a) and explicit stereotype application (b) as a function of pattern detection ability in Study 2. Note that Figure 3a depicts raw RT differences for ease of interpretation; the analysis was conducted on log transformed data to satisfy regression assumptions.

Study 2 extended our initial findings by differentiating two unique aspects of stereotyping. We found that participants with superior pattern detection abilities showed greater implicit activation of stereotypes as well as greater explicit application of stereotypes relative to participants with inferior pattern detection abilities. These findings are broadly consistent with other work documenting a positive relationship between cognitive ability and intergroup bias (Glaser, 2001; Katz, 1990; Steininger & Colsher, 1979; Wodtke, 2016). Superior pattern detectors are adept at learning the behavioral traits of novel social groups and subsequently both activating and applying that knowledge when evaluating individual category members.

Study 3

Thus far, we have uncovered a consistent link between pattern detection and stereotyping. The same general trend emerged whether stereotyping was assessed with categorical misidentification (Study 1), implicit activation (Study 2), or explicit application (Study 2). Although the findings described up to this point were internally consistent, two additional points deserve mention. First, our initial studies assessed stereotypes about novel alien categories. This procedure provided experimental control for assessing both the initial learning and subsequent use of stereotypes, but it was also different from stereotyping as it applies to other people. Second, although the initial studies assessed stereotyping using well-established techniques (e.g., lexical-decision task), the novel social category made the stakes relatively low. Stereotypes have garnered so much empirical attention because they often result in harmful behaviors (Correll, Park, Judd, & Wittenbrink, 2002; Eberhardt, Davies, Purdie-Vaughns, & Johnson, 2006). It remains to be seen whether pattern detection is associated with stereotyping when the stakes are higher—for instance, when the targets in question are other people for whom stereotype application will have a negative effect.

Motivations for stereotype suppression were largely absent from Studies 1–2 because of the hypothetical nature of the task and the novel social category of aliens. As such, there may have been greater concordance between stereotype activation and stereotype application than we would expect to see in the real world, where egalitarian norms come into play. In these cases, superior pattern detectors may draw upon cognitive resources to tamp down stereotyping and protect unknown others from harm, consistent with predictions derived from the enlightenment perspective (McCourt et al., 1999; Scarr et al., 1981). It is also possible that superior pattern detectors will continue to apply stereotypes in a self-serving manner, consistent with predictions derived from the ideological refinement perspective (Glaser, 2001; Jackman & Muha, 1984; Wodtke, 2016). Study 3 sought to extend our findings to human targets and a behavioral measure of stereotyping with tangible, real-world outcomes.

Method

Participants. One hundred fifty-three Mechanical Turk users (45% male, 75% White, M_{age} = 31.74 years, SD_{age} = 9.99 years) completed the study. Note that the sample is smaller than in our previous studies. For this and all subsequent studies, we decided our stopping rule for data collection based upon a power analysis

of the sample size necessary to detect the average effect size observed in Studies 1 and 2 (N = 160).

Procedure. Participants completed a series of ostensibly unrelated tasks described as a pilot test for future research. The first task was presented as a test of person memory. Similar to Studies 1 and 2, participants viewed 36 targets paired with one-sentence behavioral descriptions with the goal of memorizing which behavior went with which target. Instead of aliens, however, the targets in this study were realistic male faces. We created stimuli using FaceGen Modeler (Blanz & Vetter, 1999), which estimates facial phenotypes based on several hundred three-dimensional scans of real people. We set all phenotypic features at their population average and created 36 unique identities. Next, we systematically manipulated one feature of each identity—sellion width (i.e., the upper part of the nose bridge). Specifically, we made the sellion on one half of the faces two standard deviations narrower than the population average and we made the sellion on the other half of the faces two standard deviations wider than the population average (see Figure 4). We paired stimuli with behaviors such that 80% of the faces with a narrow sellion were friendly and 80% of the faces with a wide sellion were unfriendly.[2] As before, participants viewed each slide individually and in random order, advancing at their own pace.

We told participants we were interested in their ability to remember the face and behavior pairings after a brief delay, so they next completed an intermittent task that was ostensibly unrelated to the first. This second task was a monetary trust game that purportedly involved other participants. We took several steps to enhance the naïve realism of the game. First, we stressed to participants that they were playing for real money, urging them to make their decisions carefully to maximize profits. Second, before the game began, participants selected an avatar from a large set of faces that would represent them to other players. Third, each trial of the trust game began with a delay of random length (1,000 ms −10,000 ms) while the computer was purportedly finding a new partner for them to play with. In reality, there were no partners; participants were presented with a fixed set of avatars presented in random order.

The trust game happened iteratively, such that participants had a new partner on each round. At the beginning of the game, participants were led to believe they had been randomly assigned to the role of Player 1, who was designated as the "giver." On each trial, they received $1.00 and had an opportunity to give some amount of that money to their partner (five options: $0.00, $0.25, $0.50, $0.75, $1.00). Whatever amount they gave to their partner would then be tripled, and the partner could return as much or as little money as they wanted to the participant. For example, if the participant allocated $0.50 to their partner, the partner would hypothetically receive $1.50 they could then split between the two

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[2] A pilot test revealed no preexisting associations between behavioral traits and sellion width. Thirty-three Mechanical Turk participants viewed a subset of male faces varying in sellion width in random order and rated each one in terms of its attractiveness, warmth, aggressiveness, and intelligence (1 = *not at all* to 9 = *extremely*). There were no significant differences between faces with a wide sellion and a narrow sellion in ratings of attractiveness (p = .880), warmth (p = .454), aggressiveness (p = .226), or intelligence (p = .300). Thus, differences in behavior toward the faces in Study 4 are not attributable to baseline trait inferences related to sellion width.
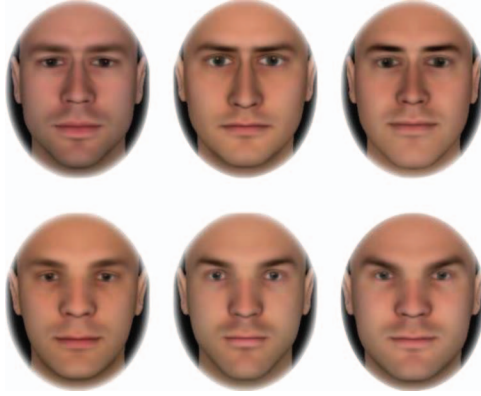
Figure 4. Sample alien targets differing in sellion width (i.e., the width of the upper nose bridge). Faces in the top row have a narrow sellion (−2 *SD* from the population mean); faces in the top row have a wide sellion (+2 *SD* from the population mean). See the online article for the color version of this figure.

parties as they saw fit. We did not provide feedback about monetary gains on a trial-by-trial basis to ensure participants did not make inferences about the friendliness of facial traits embodied by the avatars. Instead, participants believed they would learn about their total earnings at the end of the study.

The trust game involved 12 rounds, each one supposedly involving a different partner. On eight of the rounds, participants were paired with a partner whose avatar varied in sellion width (4 wide, 4 narrow). These avatars were created in the same method described above for the learning task, but they differed in identity so that we could test whether participants generalized stereotypes form one group to novel targets that shared features with that group. The other four rounds involved female avatars with no systematic variability in sellion width, which were intended as distractors to reduce the likelihood participants would guess the study's intent.

After finishing the trust game, participants completed the test of pattern detection ability from Study 1. Only then did they learn there would be no memory test of the faces presented during the learning phase. Instead, they provided demographic information and were debriefed about the study aims.

Results and Discussion

We calculated the proportion of correct matrix responses for each participant as a measure of pattern detection ability ($M = 0.38$, $SD = 0.21$). We operationalized stereotyping in the trust game as a tendency to give more money to partners whose avatars had a narrow sellion (which was paired with friendly behavior during the learning phase) than to partners whose avatars had a wide sellion (which was paired with unfriendly behavior during the learning phase). Specifically, we subtracted the average amount of money participants gave to partners whose avatars had a wide sellion from the average amount of money participants gave to partners whose avatars had a narrow sellion. Thus, higher values indicated trust game behaviors that were consistent with the stereotypes presented in the learning phase.

Before conducting analyses, we decided to exclude participants who indicated they had completed behavioral trust games on

Mechanical Turk in the past and who had no variability in their responses (i.e., gave the same amount of money to partners on every trial). The remaining sample of 98 participants provided more than 80% power to detect medium effects ($r = .30$), consistent with effect sizes from Studies 1 and 2.

We began by testing whether participants allocated money in a stereotype-consistent manner during the trust game overall. Recall that we subtracted each participant's average monetary allocation to avatars with a wide sellion from their average monetary allocation to avatars with a narrow sellion, such that positive values indicated stereotype-consistent behavior. We subjected these scores to a one-sample *t* test against a null value of 0. Indeed, participants behaved in a stereotype-consistent manner during the trust game, offering about \$0.13 less per trial ($M = 0.13$, $SD = 0.06$) to partners whose avatars had a wide compared with a narrow sellion, $t(98) = 12.14$, $p < .001$, $d = 1.22$. This finding serves as a manipulation check indicating that participants learned the association between sellion width and friendliness of male faces.

We next turned to our focal analysis of trust game behavior as a function of pattern detection ability. We regressed the difference in each participant's monetary allocation between avatars with a wide sellion and a narrow sellion onto their score from the pattern detection test. As in the prior studies, superior pattern detectors behaved in a more stereotype-consistent manner than did inferior pattern detectors. Specifically, superior pattern detectors gave more money to avatars with narrow as opposed to wide sellions, $B = 1.38$, $SE = 0.59$, $t = 2.36$, $p = .020$, $R^2 = 0.05$ (see Figure 5).

Study 3 revealed that superior pattern detectors acted in a stereotype-consistent fashion during a behavioral trust game, offering less money to partners whose avatars had facial features that were previously linked to unfriendly behaviors as opposed to
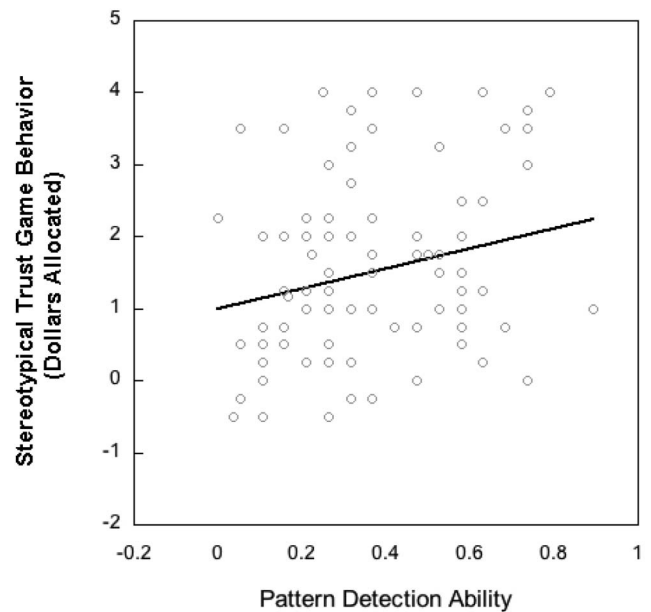

Figure 5. Stereotype-consistent trust game behavior as a function of pattern detection ability in Study 3.

friendly behaviors. These effects emerged despite the fact that trust game avatars were presumably unrelated to the faces presented in the learning task. Indeed, instructions led participants to believe the trust game was unrelated to the learning phase and we deliberately included a series of distractor faces to reduce expectancy effects. Nevertheless, superior pattern detectors generalized their knowledge of the stereotypical association between sellion width and friendliness from the learning phase to novel targets encountered during the trust game.

These findings are noteworthy for two reasons. First, they replicate our previous findings linking pattern detection ability and stereotyping using realistic human faces as targets. Second, they extend these findings to include behavioral outcomes with real-world implications. The positive association we have uncovered between pattern detection abilities and stereotyping therefore does not appear to be an artifact of the fictional targets used in Studies 1–2. Even when the stakes are relatively high, superior pattern detectors behave in a stereotype-consistent manner, withholding trust from people who resemble faces previously associated with unfriendly as opposed to friendly behaviors.

Study 4

Pattern detection is an essential human aptitude that is highly correlated with measures of both fluid intelligence and general intelligence (Alderton & Larson, 1990; Carpenter et al., 1990; Conway et al., 2002; Fry & Hale, 2000). Although highly correlated, however, pattern detection is at least partially distinct from general intelligence measures. Because our preliminary studies only examined one aspect of intelligence based on pattern recognition, the extent to which other cognitive abilities contribute to stereotype processes remains to be seen. One possibility is that the stereotype effects observed above are specifically related to pattern recognition ability. In this case, accounting for performance on another cognitive task might reduce the magnitude of association between pattern detection and stereotyping, but would not eliminate it. Another possibility is that pattern detection is a proxy for more general cognitive ability. In this case, accounting for performance on another cognitive task should fully eliminate the association between pattern detection and stereotyping. Study 4 tested these possibilities to clarify the uniqueness of pattern detection as a cognitive ability associated with stereotyping.

Method

Participants. One hundred seventy-two Mechanical Turk users (51% male, 83% White, $M_{age} = 33.10$ years, $SD_{age} = 9.44$ years) completed the study.

Procedure. Participants completed a series of ostensibly unrelated tasks described as a pilot test for future research. The first task was presented as a test of person memory. Participants viewed 36 realistic male faces alongside behavioral descriptions, with the goal of memorizing which face was paired with which behavior. As in Study 3, 80% of the faces with a narrow sellion were paired with friendly behaviors and 80% of the faces with a wide sellion were paired with unfriendly behaviors.

After the learning phase, participants completed three additional tasks in counterbalanced block order. These tasks were again presented as fillers to pass time before the memory test. One of the tasks utilized an affect misattribution procedure (AMP; Payne, Cheng, Govorun, & Stewart, 2005) to assess implicit stereotyping. On each trial, participants were presented with a prime face (75 ms) followed by a blank screen (125 ms), Chinese pictograph (100 ms), and backward mask (until response). They had to indicate whether each pictograph was less or more visually appealing than average using their computer keyboard. The prime faces differed in identity from those presented in the learning phase, but they varied systematically in sellion width (5 narrow, 5 average, 5 wide). Each prime face was presented four times in random order, for a total of 60 AMP trials.

Another task assessed probabilistic category learning using the Weather Prediction Task (WPT; Knowlton, Squire, & Gluck, 1994), a well-validated procedure for assessing fluid intelligence (Aron, Gluck, & Poldrack, 2006; Knowlton et al., 1994). Specifically, participants were introduced to a series of four cards marked with different patterns. Each card was associated with a unique probability of predicting bad weather (rain) or good weather (shine), but participants did not know the probabilities up-front. Instead, they were tasked with learning to predict the weather through iterative guessing. On each trial, participants saw a set of 1, 2, or 3 cards and had to make a prediction about the weather based upon those cards. Participants received feedback about the accuracy of their judgments on a trial-by-trial basis so they could inductively learn the probability rules for predicting weather. They completed 200 trials presented in random order.

In the remaining task, participants completed the matrix test from the previous studies as a measure of pattern detection ability. Finally, they reported demographic information and were debriefed about the study aims.

Results and Discussion

We calculated the proportion of correct responses on the matrix test as a measure of pattern detection ability ($M = 0.36$, $SD = 0.20$). We operationalized probabilistic category learning based on responses to the Weather Prediction Task. For each participant, we calculated the total number of correct predictions (rain vs. shine) over 200 trials ($M = 122.21$, $SD = 19.52$). Higher values therefore indicated more efficient learning of the probabilities associated with each card, which is thought to reflect fluid intelligence. We operationalized implicit stereotyping based on responses the Affect Misattribution Procedure. Specifically, we calculated the total number of trials on which participants rated the Chinese pictograph in a manner that was stereotypically consistent with the face prime. We did so by subtracting the number of trials on which participants rated pictographs as more attractive than average following a wide sellion prime (which was previously associated with unfriendly behavior) from the number of trials on which participants rated the pictograph as more attractive than average following a narrow sellion prime (which was previously associated with friendly behavior). Thus, higher values indicated stereotype-consistent ratings, with pictographs appearing less attractive after exposure to facial features previously linked to unfriendly behavior compared with friendly behavior. We present separate

findings for the Weather Prediction Task and Affect Misattribution Procedure below.

Stereotyping (Affect Misattribution Procedure). We began by testing whether participants responded in a stereotype-consistent manner during the Affect Misattribution Procedure. Recall that we created a difference score such that higher values indicated more stereotype-consistent judgments (i.e., narrow sellion primes leading to higher attractiveness ratings of the pictographs than wide sellion primes). We subjected these scores to a one-sample t test against a null value of 0. Results indicated that participants rated nearly 6 more Chinese pictographs ($M = 5.79$, $SD = 6.93$) as attractive after exposure to narrow sellion primes relative to wide sellion primes, $t(171) = 10.96$, $p < .001$, $d = 0.84$. This finding serves as a manipulation check indicating that participants internalized the association between sellion width and friendliness during the learning phase.

We then turned to our focal analysis of stereotyping as a function of pattern detection ability. We regressed each participant's number of stereotypical responses from the Affect Misattribution Procedure onto their score from the pattern detection test. Consistent with the previous studies, superior pattern detectors responded to the pictographs in a more stereotype-consistent manner than did inferior pattern detectors, $B = 6.55$, $SE = 2.78$, $t = 2.36$, $p = .020$, $R^2 = 0.05$ (Figure 6a).

Probabilistic category learning (Weather Prediction Task). Next, we tested whether participants effectively learned the probabilistic rules associated with various cards in the Weather Prediction Task. Recall that we calculated responses as the total number of correct judgments over the course of the task. We subjected this measure to a one-sample t test against a null value of 100 (i.e., 50% accuracy). Overall, category learning was significantly greater than would be expected by chance ($M = 122.21$, $SD = 19.52$), $t(157) = 14.30$, $p < .001$, $d = 1.14$. This finding serves as a manipulation check, indicating that participants were able to effectively discern the probability rules governing the weather.

Next, we tested whether pattern detection ability was associated with performance on the weather prediction task. We regressed each participant's number of correct weather predictions onto their score from the pattern detection test. Superior pattern detectors showed enhanced probabilistic learning, generating significantly more correct weather predictions than inferior pattern detectors, $B = 43.04$, $SE = 7.17$, $t = 6.01$, $p < .001$, $R^2 = 0.20$ (Figure 6b). These findings map onto earlier work suggesting that pattern detection is a core element of fluid intelligence.

Linking performance on cognitive and social tasks. Finally, we tested the amount of shared variance in abilities underlying the cognitive reasoning task and the social judgment task. We began by regressing each participant's score from the Affect Misattribution Procedure onto their score from the Weather Prediction Task. The effect was significant, indicating that participants who were faster to learn probabilities in the Weather Prediction Task tended to show greater evidence of implicit stereotyping during the Affect Misattribution Procedure, $B = 0.06$, $SE = 0.03$, $t = 2.16$, $p = .033$. Next, we tested whether pattern detection ability statistically accounted for this effect in a series of nested linear regressions. In the first model, we regressed scores from the Affect Misattribution Procedure onto pattern detection ability. In the second model, we added scores from the Weather Prediction Task to the regression equation. After accounting for the effects of pattern detection ability, WPT performance had no reliable impact on model fit, $\Delta R^2 = 0.01$, $F(1, 147) = 0.96$, $p = .328$.

Study 4 revealed substantial overlap among a reasoning task that measures fluid intelligence and a social task that measures implicit stereotyping. Both tasks were associated with pattern detection ability: Superior pattern detectors had more correct judgments in the Weather Prediction Task and more stereotype-consistent responses in the Affect Misattribution Procedure. Moreover, performance on the Weather Prediction Task and the Affect Misattribution Procedure was highly correlated. Statistically controlling for pattern detection ability eliminated this association between scores on the Weather Prediction Task and the Affect Misattribution Procedure. Thus, probabilistic reasoning and social stereotyping are guided by an overlapping set of cognitive abilities.
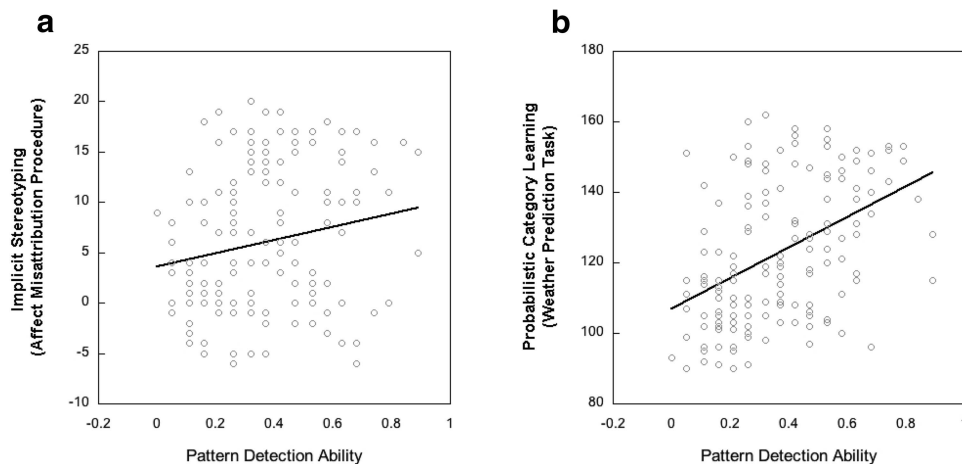
Figure 6. Implicit stereotyping (a) and probabilistic category learning (b) as a function of pattern detection ability in Study 4.

Study 5

Studies 1–4 paint a somewhat bleak portrait of cognitive ability, indicating that strong pattern detectors learn, activate, and apply stereotypes more readily than weak pattern detectors. Before hastening to conclusions about the drawbacks of superior cognitive ability, however, it is important to recognize that stereotypes are malleable. Over the past decade, a number of studies have shown that stereotypical knowledge can be dynamically updated on the basis of new information about a target group (Blair, 2002; Diekman & Eagly, 2000; Hugenberg, Blusiewicz, & Sacco, 2010). For example, training paradigms that expose people to counterstereotypic information have been shown to reduce both activation and application of relevant stereotypes (Dasgupta & Asgari, 2004; Kawakami, Dovidio, Moll, Hermsen, & Russin, 2000; Kawakami, Dovidio, & van Kamp, 2005). Because superior pattern detectors demonstrate efficient learning of stereotypic information for novel groups, we wondered whether they might also update their stereotypes on the basis of new information. Study 5 tested this possibility that pattern detection ability predicts stereotype change.

Method

Participants. Two hundred four Mechanical Turk users (50% male, 75% White, M_{age} = 33.07 years, SD_{age} = 10.65 years) completed the study.

Procedure. Participants completed a series of ostensibly unrelated tasks described as a pilot test for future research. In the first task, participants completed a learning phase similar to Study 3. They viewed a series of realistic male faces paired with one-sentence behavioral descriptions, wherein most faces with a narrow sellion performed friendly behaviors and most faces with a wide sellion performed unfriendly behaviors. The only difference from Study 3 was that we used half the number of learning trials (18 total). After completing the initial learning phase, participants moved onto a second task that was ostensibly unrelated to the first. Specifically, they played 6 rounds of the trust game described in Study 3. On each trial, participants decided how much money ($0.00, $0.25, $0.50, $0.75, $1.00) to allocate to a partner represented by an avatar (2 with narrow sellion, 2 with average sellion, 2 with wide sellion).

After the initial trust game, participants were told they had additional faces to memorize and thus completed a second learning phase of 18 trials followed by a second trust game of 6 trials. Although participants were not informed of any difference in the task, the second phase of the study reversed the association between sellion width and behavior. That is, during the learning phase, faces with a narrow sellion were now paired with unfriendly behavior and faces with a wide sellion were now paired with friendly behavior. This procedure allowed us to test the updating of stereotypes as a function of new information, as the association between friendly behavior and sellion width was opposite of the initial learning phase.

After completing both learning phases and trust games, participants completed 19 matrix problems to test their pattern detection ability. Finally, they provided demographic information and were debriefed about the study aims.

Results and Discussion

We calculated the proportion of correct matrix problems for each participant as a measure of pattern detection ability (M = 0.38, SD = 0.19). We operationalized stereotyping as the tendency to give more money to trust game avatars with a narrow sellion as opposed to avatars with a wide sellion. That is, we subtracted the average amount of money participants gave to partners whose avatars had a wide sellion from the average amount of money participants gave to partners whose avatars had a narrow sellion for each round of the trust game. Higher values in the first round of the trust game and lower values in the second round of the trust game therefore indicated behaviors that were stereotypically consistent with the preceding learning phase.

Similar to Study 3, we made the a priori decision to exclude responses from participants who indicated they had completed behavioral trust games on Mechanical Turk in the past and who had no variability in their responses (i.e., gave the same amount of money to partners on every trial). The remaining sample of 133 participants provided more than 80% power to detect medium effects (r = .30), consistent with effect sizes from our prior studies.

Trust game (Round 1). We began by testing whether participants behaved in a stereotype-consistent manner during the first round of the trust game. Recall that the initial learning phase paired narrow sellions with friendly behavior and wide sellions with unfriendly behavior, and that our outcome measure subtracted monetary allocations to avatars with wide sellions from monetary allocations to avatars with narrow sellions. Thus, positive values indicated stereotype-consistent behavior in the first round of the trust game. We subjected these scores to a one-sample t test against a null value of 0. Overall, participants behaved in a stereotype-consistent manner during the first round of the trust game, $t(131)$ = 10.06, p < .001, d = 0.88. This finding serves as a manipulation check indicating that participants internalized the association between sellion width and friendliness during the initial learning phase.

We then turned to our focal analysis of the association between trust game behavior and pattern detection ability. We regressed the difference in each participant's monetary allocation between avatars with a wide sellion and a narrow sellion onto their score from the pattern detection test. Replicating the results from Study 3, superior pattern detectors behaved in a more stereotype-consistent manner than did inferior pattern detectors, B = 1.54, SE = 0.59, t = 2.60, p = .010, R^2 = 0.05.

Trust game (Round 2). Next, we examined stereotyping in the second round of the trust game. Recall that the second learning phase reversed the original stereotype, pairing wide sellions with friendly behavior and narrow sellions with unfriendly behavior. We again subtracted participants' monetary allocations to avatars with wide sellions from their monetary allocations to avatars with narrow sellions, such that negative values indicated stereotype-consistent behavior in the second round of the trust game. We subjected these scores to a one-sample t test against a null value of 0. Overall, participants behaved in a stereotype-consistent manner during the second round of the trust game, $t(131)$ = −2.60, p = .010, d = 0.23. This finding serves as a manipulation check indicating that participants internalized the association between sellion width and friendliness during the second learning phase.

We also explored the association between trust game behavior in round two and pattern detection ability. Specifically, we regressed the difference in each participant's monetary allocation to avatars with wide sellions compared with narrow sellions in round two onto their score on the pattern detection test. Pattern detection ability did not significantly predict trust game outcomes in round two, $B = -0.72$, $SE = 0.73$, $t = -0.99$, $p = .322$, $R^2 = 0.01$. The null result is not necessarily surprising since the second learning phase required participants to reverse the direction of stereotyping. Superior pattern detectors may have updated their stereotypes to accommodate new information, reversing the direction of monetary allocation in the second round of the trust game. Inferior pattern detectors may not have updated their stereotypes as readily, carrying over their original stereotypes into round two. Such carry-over effects might have weakened the overall difference in stereotyping during round two of the trust game, reducing the chances of detecting a significant effect.

Trust game (Change). Our primary hypothesis in Study 5 was that superior pattern detectors would show greater *change* in stereotyping from round one to round two than would inferior pattern detectors. To test this hypothesis, we created a stereotype change variable by subtracting round two trust game outcomes from round one trust game outcomes. Positive values indicated stereotype change in the appropriate direction given the sequence of learning phases (i.e., more money given to avatars with narrow relative to wide sellion at posttest relative to pretest). We regressed this measure of stereotype change onto pattern detection ability. As predicted, superior pattern detectors showed greater stereotype change consistent with the learning phases in round one and round two than did inferior pattern detectors, $B = 2.27$, $SE = 1.05$, $t = 2.16$, $p = .033$, $R^2 = 0.03$ (see Figure 7).
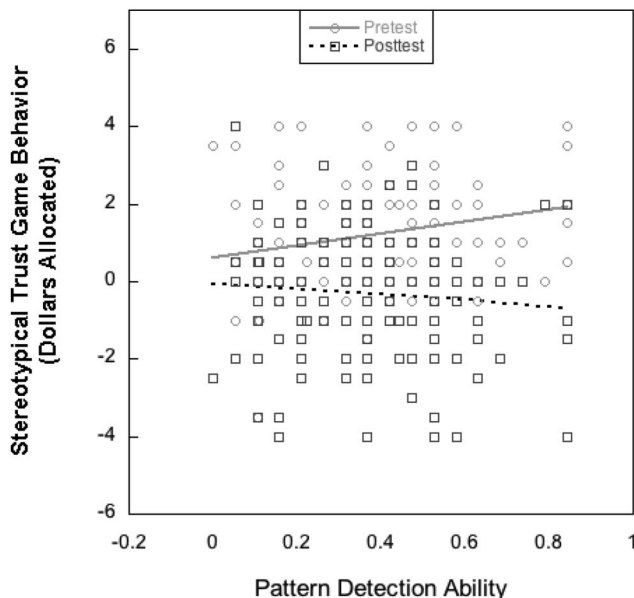

Figure 7. Stereotype-consistent trust game behavior as a function of pattern detection ability in Study 5. The direction of stereotype learning was reversed at pretest and posttest, such that positive values indicate stereotype-consistent behavior at pretest but negative values indicate stereotype-consistent behavior at posttest.

Study 5 offers an important clarification to our conclusions regarding the association between pattern detection and stereotyping. Although superior pattern detectors tend to learn, activate, and apply stereotypes more readily than inferior pattern detectors, they also update those stereotypes with relative ease. Indeed, when presented with exemplars who negated the earlier association between visible cues and antisocial behavior, superior pattern detectors switched their pattern of stereotyping to accommodate the new information. The update happened quickly, with superior pattern detectors showing a full switch in the direction of stereotyping after just 18 trials. By contrast, inferior pattern detectors learned the initial stereotypes well enough to show evidence of stereotypical behavior patterns in the first round of the trust game, but they did not reverse the direction of these behaviors following exposure to counterstereotypical exemplars. Although learned less readily, inferior pattern detectors appear to maintain stereotypes with greater rigidity than superior pattern detectors.

Study 6

Although our findings have revealed consistent associations between pattern detection abilities and stereotyping, the preceding studies examined novel stereotypes of fictitious targets. Studies 1–2 involved behavioral traits of alien creatures, and Studies 3–5 involved fallacious links between human sellion width and friendliness. These designs provided the experimental control necessary to test the learning and updating of stereotypes without confounds related to prior exposure, but they leave open questions about how pattern detection relates to existing stereotypes. Do superior pattern detectors activate and apply existing stereotypes to real social groups in the same way they do for novel stereotypes? Or do additional cognitive resources enable them to avoid existing stereotypes? Study 6 addressed these questions, building upon our prior work by testing whether pattern detection ability predicts the magnitude of stereotype change following an established counterstereotype training paradigm.

Method

Participants. Two hundred eleven Mechanical Turk users (36% male, 77% White, $M_{age} = 35.30$ years, $SD_{age} = 10.15$ years) completed the study.

Procedure. Participants completed a series of ostensibly unrelated tasks described as pilot tests for future research. The first phase of the study was a primed Stroop task used to measure of implicit gender stereotyping (Kawakami, Dion, & Dovidio, 1999). The task was based on the classic Stroop interference paradigm (Stroop, 1935), in which participants view color words (e.g., RED, YELLOW, BLUE) printed in various colored inks (e.g., green ink, red ink, blue ink) and are tasked with naming the color of the ink as quickly as possible while ignoring word. Responses tend to be slower when the word and color are inconsistent (e.g., RED printed in green ink) than when they are consistent (e.g., RED printed in red ink), revealing interference of the semantic content on color judgments. We applied the same basic procedure to test the accessibility of gender stereotypes. On each trial, participants saw a fixation cross (300 ms) followed by a blank screen (500 ms), prime word (950 ms), blank screen (50 ms), and target word (until response). The prime words were always MALE or FEMALE; the

target words were six stereotypic traits of women (*dependent, helpful, insecure, open, social, submissive*) and six stereotypic traits of men (*authoritative, competitive, dominant, intimidating, pioneering, risky*) printed in each of four colors (*red, blue, green, yellow*). Participants were instructed to ignore the prime word and focus on the color of the target word. They completed 96 trials in random order, indicating the color of the target word as quickly as possible via button press.

After the Stroop task, participants completed the 19 matrix problems from Study 1 assessing pattern detection ability. Next, half of the participants were randomly assigned to a counterstereotype training procedure based on prior research (Kawakami et al., 2000). Here, participants were presented with images of men and women in the center of the screen. Under each image were 2 trait words—one trait that was stereotypically consistent with the target's sex and one trait that was stereotypically inconsistent with the target's sex. Participants indicated via button press the trait that was *inconsistent* with gender stereotypes. If they answered correctly, they immediately proceeded to the next trial. If they answered incorrectly, they received feedback ("INCORRECT! Please select the trait word that is *inconsistent* with the person in the photograph.") for 2000 ms before proceeding to the next trial. Stimuli for the counterstereotype training included 40 facial photographs (20 male, 20 female) from the Chicago Face Database and 40 trait words from prior research on gender stereotyping (20 male stereotypes −10 positive, 10 negative; 20 female stereotypes – 10 positive, 10 negative; Kawakami et al., 1999). Images and traits were paired randomly throughout the training phase with the constraint that each image was accompanied by one stereotype-consistent trait and one stereotype-inconsistent trait that were matched in valence (i.e., both positive or both negative). In total, the training phase included 8 practice trials and 480 critical trials separated into 6 blocks of 80 trials each. Between blocks, participants had an opportunity to take a self-paced break before continuing.

Finally, all participants completed a posttest stereotyping task that was identical to the Stroop interference task from pretest. Participants then provided demographic information and were debriefed about the study aims.

Results and Discussion

We calculated the proportion of matrix problems each participant answered correctly as a measure of pattern detection ability ($M = 0.42$, $SD = 0.20$). We operationalized stereotyping on the basis of response latencies in the Stroop task. Specifically, we aggregated participants' average response latencies for trials on which the prime and target were stereotypically congruent (e.g., FEMALE and submissive) and for trials on which the prime and target were stereotypically incongruent (e.g., FEMALE and authoritative) at both pretest and posttest. We then subtracted latencies for the congruent trials from latencies for the incongruent trials, such that positive values indicated greater implicit stereotyping (i.e., slower responses for incongruent trials relative to congruent trials). Finally, we created a difference score by subtracting implicit stereotyping at posttest from implicit stereotyping at pretest, such that higher values indicated greater stereotyping before training as opposed to after training.

We began by testing whether participants showed evidence of implicit gender stereotyping at pretest and posttest. Recall that we coded Stroop performance such that higher values indicated greater stereotyping (i.e., slower responses for stereotypically incongruent trials relative to stereotypically congruent trials). We subjected the pretest and posttest stereotyping measures to one-sample t tests against a null value of 0. Overall, participants showed implicit activation of gender stereotypes at pretest, ($M = 93.90$, $SD = 201.15$), $t(210) = 6.78$, $p < .001$, $d = 0.47$, as well as posttest, ($M = 99.62$, $SD = 170.90$), $t(210) = 8.47$, $p < .001$, $d = 0.58$. These findings replicate prior work using the primed Stroop task to measure gender stereotyping.

Next, we turned to our focal hypothesis regarding pattern detection ability. We first explored simple associations between pattern detection ability and gender stereotyping. Specifically, we individually regressed stereotype scores from pretest and posttest onto pattern detection ability. Although the means were in the expected direction, pattern detection ability did not significantly predict implicit gender stereotyping at pretest, $B = 114.41$, $SE = 70.82$, $t = 1.62$, $p = .108$, $R^2 = 0.01$, or at posttest, $B = 84.58$, $SE = 60.26$, $t = 1.40$, $p = .162$, $R^2 = 0.01$. This finding is somewhat inconsistent with our previous studies, which repeatedly showed that pattern detection was associated with stereotyping. Nevertheless, we argue that the weaker effect in Study 6 is not surprising because we are now dealing with a preestablished stereotype that varies considerably in magnitude across persons. Furthermore, the activation and application of real gender stereotypes are likely to be driven by many factors other than cognitive ability (e.g., personal endorsement of the stereotype), which play a greater role in the current study compared with the previous studies. Finally, it seems reasonable to expect that superior pattern detectors are especially likely to learn and use stereotypes early in their encounters with a social group; over time, however, inferior pattern detectors may catch up and have stereotypes of equal magnitude. Any or all of these possibilities may help to explain the relatively weaker difference in stereotyping between inferior and superior pattern detectors in Study 6.

Critically, however, the overall association between pattern detection and stereotyping does not account for counterstereotype training. In a final analysis, we regressed the amount of change in implicit gender stereotyping from pretest to posttest onto pattern detection ability, counterstereotype training condition, and their interaction. The expected two-way interaction emerged, $B = 256.35$, $SE = 98.03$, $t = 2.62$, $p = .010$, $R^2 = 0.03$. We decomposed the interaction by examining simple effects of pattern detection ability within each training condition. Pattern detection ability was not associated with a change in gender stereotyping from pretest to posttest for participants in the control condition, $B = -85.52$, $SE = 65.41$, $t = -1.31$, $p = .193$. However, pattern detection ability was associated with a change in stereotyping from pretest to posttest in the counterstereotype training condition, $B = 170.83$, $SE = 73.02$, $t = 2.34$, $p = .020$. Among participants who underwent counterstereotype training, superior pattern detectors showed a greater reduction in implicit gender stereotyping compared with inferior pattern detectors.

Study 6 extended our prior insights to include links between pattern detection ability and activation of existing stereotypes about real social groups. At pretest, we did not find an association between pattern detection ability and stereotyping. Although the

means were in the predicted direction, the tendency for superior pattern detectors to activate gender stereotypes more strongly than inferior pattern detectors was not statistically significant. It is difficult to interpret null effects, but one explanation for the lack of significance is that the stereotypical traits used in the Stroop task were validated 20 years ago. As women have gained more equal representation in positions of power, stereotypes linking women to traits like dependent, insecure, social, and submissive may have begun to erode. If superior pattern detectors picked up on these trends, they may show less stereotype activation based on older associations. Another possibility is that Study 6 assessed stereotypes with verbal primes, whereas the other studies used visual primes (i.e., faces). Perhaps our pattern detection measure picked up stereotypes evoked by visual cues more so than verbal cues, dampening the baseline effect in Study 6. Finally, compared with novel stereotypes, the activation and application of existing stereotypes could be moderated by numerous between-person factors (e.g., statistical learning, stereotype endorsement, motivation to control bias). Variability in these factors may have drowned out the impact of cognitive ability at baseline, making it difficult to detect a significant effect.

Those observations notwithstanding, our focal analysis comparing the change in stereotyping activation as a function of pattern detection ability and counterstereotype training was as predicted. Specifically, we found that superior pattern detectors were especially sensitive to counterstereotype training. After repeatedly pairing male and female targets with traits that were inconsistent with gender stereotypes, superior pattern detectors showed a greater reduction in implicit gender stereotyping than did inferior pattern detectors. These findings provide two valuable pieces of information. First, they replicate the finding from Study 5 that superior pattern detectors efficiently update stereotypes when presented with contradictory information. Second, they extend those findings to include real stereotypes that have a direct impact on contemporary social groups. Our findings also contribute new information to the literature on stereotype change. Early studies indicated that, when confronted with counterstereotypical information, perceivers tend to form subtypes (i.e., category exceptions that are considered unrepresentative of the overall group; Hewstone, 1994; Hewstone, Macrae, Griffiths, Milne, & Brown, 1994). More recent studies have revealed that stereotypes can be reliably updated following repeated exposure to counterstereotypical exemplars (Dasgupta & Asgari, 2004; Kawakami et al., 2000, 2005). The current data highlight pattern detection ability as an important and previously unrecognized moderator of such updating.

General Discussion

Six studies provided evidence for an association between pattern detection ability and stereotyping. In Study 1, participants were exposed to a set of alien creatures in which most of the blue-colored aliens performed unfriendly behaviors and most of the yellow-colored aliens performed friendly behaviors. Participants with strong pattern detection ability were more likely than those with weak pattern detection ability to make stereotype-consistent errors when attributing behaviors to novel targets in a subsequent memory test (e.g., misattributing an unfriendly behavior to the wrong blue-colored alien). Study 2 distinguished between two aspects of stereotyping: stereotype activation and stereotype ap-

plication. Compared to participants with weaker pattern detection abilities, those with stronger pattern detection abilities showed greater implicit activation as well as greater explicit application of stereotypes linking alien colors to behavioral tendencies (i.e., blue = unfriendly, yellow = friendly). Study 3 extended these effects beyond abstract judgments of fictional aliens, instead using realistic human faces as targets and a behavioral trust game with monetary outcomes as a measure of stereotyping. Here again, superior pattern detectors displayed heightened stereotyping, offering less money in the trust game to partners whose facial features were similar to those of targets previously linked with unfriendly behavior. Study 4 sought to test the extent of this overlap between cognitive ability and intergroup evaluation. We uncovered strong correlations among pattern detection ability (Raven's Matrices), a classic cognitive measure of probabilistic category learning (Weather Prediction Task), and behavioral stereotyping (monetary trust game). Accounting for performance on the Weather Prediction Task eliminated the association between pattern detection ability and stereotyped behavior in the trust game, highlighting pattern detection as a common underpinning to both cognitive learning and social evaluation tasks.

Studies 1–4 painted a bleak picture of the association between cognitive ability and stereotyping, suggesting that people with superior pattern detection skills learn, activate, and apply stereotypes more readily than others. Still, the fact that superior pattern detectors efficiently learned behavioral information about novel social categories suggested they might also update their stereotypes when confronted with new information. Study 5 revealed that superior pattern detectors readily update their stereotypes: When presented with exemplars displaying counterstereotypical behavior, superior pattern detectors fully switched their pattern of stereotyping to accommodate the new information. Study 6 extended these findings about stereotype updating using established counterstereotype training procedures. We found that superior pattern detectors showed greater reductions in implicit gender stereotyping following counterstereotype training than did inferior pattern detectors. These findings help to rule out cognitive set as a simple explanation for our findings, which would suggest that people who are quick to learn a stereotypic pattern are also likely to freeze onto that pattern, continuing to apply the stereotype even when it is no longer warranted (Luchins, 1942). However, this does not appear to be the case. People with superior pattern detection abilities appear to act as naïve empiricists, both learning and updating their stereotypes based on incoming information.

The current studies therefore uncovered consistent links between pattern detection and stereotyping across a variety of implicit, explicit, and behavioral measures. To our knowledge, these findings are the first to systematically demonstrate that cognitive ability is associated with greater stereotyping. Indeed, although previous studies investigated links between intelligence and intergroup relations broadly, the outcome measures in those studies ranged from personality factors (e.g., authoritarianism) to political orientation (e.g., conservatism), explicit prejudice (e.g., anti-Black bias), and social policy attitudes (e.g., support for nondiscrimination policies). Our work fills a gap in the existing literature, revealing that superior pattern detectors efficiently extract stereotypes about the behavior of social groups and use those stereotypes when evaluating and interacting with individual group members. Because stereotypes are distinct in form and function from con-

structs such as personality, prejudice, and policy support, our findings provide novel information about the social implications of cognitive ability.

Our findings also offer methodological advances to the literature linking cognitive ability to intergroup processes, which until now has relied mostly on self-report. Implicit and behavioral measures are especially important in this domain because people with superior cognitive abilities may be aware of norms against prejudice and respond to self-report questionnaires in socially desirable ways that make them appear less biased than others. Indeed, although prior research has tended to show low rates of prejudice among highly intelligent people, there are competing theoretical explanations for these findings. According to the enlightenment perspective, people with superior cognitive abilities are able to integrate complex information into their attitudes and ultimately form positive intergroup attitudes that support others who differ from themselves (McCourt et al., 1999; Scarr et al., 1981). According to the ideological refinement perspective, people with superior cognitive abilities may be especially adept at using stereotypes to legitimize their standing within the social hierarchy (Jackman, 1978; Jackman & Muha, 1984; Wodtke, 2013, 2016). The current findings are broadly consistent with the latter perspective, indicating that people with superior cognitive ability are not necessarily more egalitarian than others. Although our studies were not designed to test the broader mechanisms of ideological refinement (e.g., group status, power differentials, hierarchy), they provide evidence for the prediction that cognitive ability is positively associated with stereotyping. Future research would help to clarify how cognitive ability and social status interact to predict stereotyping.

We should reiterate that our study investigated pattern detection as just one of many cognitive abilities. We focused on pattern detection for two reasons. First, pattern detection is a core component of human intelligence that is included in most contemporary intelligence test batteries (Cattell, 1949; Mackintosh & Mackintosh, 2011; Thorndike et al., 1986; Wechsler, 2014). In fact, pattern detection has been called an ideal measure of human intelligence because it reliably predicts a number of other aptitudes (Carpenter et al., 1990; DeShon et al., 1995). Second, pattern detection has strong theoretical links with stereotyping, defined as the process of extracting behavioral trends about social groups and applying them to make sense of individual exemplars of that group. Pattern detection was therefore a prime candidate for the current work. Still, we emphasize that many other measures of cognitive ability—including crystallized abilities—may bear on intergroup processes. Indeed, a recent meta-analysis suggested that fluid abilities might be the weakest predictor of affective outcomes such as prejudice (Onraet et al., 2015). Moving forward, it will be important for psychologists to develop a richer knowledge of the complex and multifaceted links between various aptitudes and intergroup outcomes.

Beyond their specific implications for research linking cognitive ability to intergroup relations, the current studies also have value for the study of intergroup relations more broadly. Given the vast amount of social cognition research investigating stereotypes, it is surprising there has been little systematic investigation of how cognitive *abilities* might be associated with stereotyping. If cognitive processes play a critical role in social phenomena, then the fundamental abilities underlying those processes are likely to be

implicated as well. Indeed, our studies suggest that one aptitude in particular—pattern recognition—reliably predicts the learning, activation, and application of social stereotypes. Our findings even suggest that pattern recognition is a reliable moderator that has gone unnoticed in previous work on counterstereotype training. These observations pave the way for productive new lines of research that probe the hidden effects of cognitive ability on many other forms of social cognition.

The current studies also provide information about the time course of stereotype formation. Using a novel groups paradigm, Studies 1–5 suggest that superior pattern detectors form new stereotypes more efficiently than inferior pattern detectors. When exploring preexisting gender stereotypes, however, Study 6 revealed less pronounced differences in stereotyping as a function of cognitive ability. This suggests that stereotypes of inferior pattern detectors may catch-up with those of superior pattern detectors over time. Future research can test this timeline directly, clarifying whether and how the impact of pattern recognition ability on stereotyping changes over time as perceivers gain more experience with a particular set of beliefs.

Our work also has implications for the study of human intelligence. Existing research has largely highlighted the benefits that accompany cognitive ability (Gottfredson, 1997). For example, highly intelligent people tend to enjoy heightened academic achievement, job performance, and social mobility compared with those of lower intelligence (Deary et al., 2007; Strenze, 2007). Although considerably fewer, some studies have recognized situations in which superior cognitive ability can lead to detrimental ends (e.g., psychopathology; Olatunji et al., 2010; Van de Cruys et al., 2014). The current studies add to this emerging literature, revealing that people with strong pattern detection ability learn and apply stereotypes more readily than others. In doing so, our findings join a small body of work guiding the field toward a more balanced understanding of the consequences of human aptitudes.

Of course, the current work is not without limitations, which highlight other avenues for future research. Most importantly, five of the six studies reported here required participants to learn novel stereotypes (e.g., linking friendliness to sellion width). This approach provided a pure test of our hypotheses by controlling for individual differences in learning history, stereotype endorsement, and group membership, but it also raises questions about associations between cognitive ability and existing stereotypes. Study 6 showed that superior pattern detectors update real gender stereotypes more readily than inferior pattern detectors, though the main effect of cognitive ability on stereotyping was not significant at baseline. We discussed possible explanations for the null effect above, including changes in stimulus presentation and between-person variability in stereotype endorsement. However, additional work will be necessary to understand the conditions under which cognitive ability predicts the activation and application of preexisting stereotypes.

We should also note that our studies investigated stereotypes that were highly valenced (e.g., unfriendly behavioral tendencies), which could have notable implications for the self in a behavioral trust game. Future work should test whether cognitive ability is implicated in the activation and application of evaluatively neutral stereotypes. Furthermore, our studies assessed pattern detection ability using a well-validated aptitude measure. This approach is consistent with prior work suggesting that fluid intelligence, in-

cluding pattern detection, is largely determined by genetics (Gottfredson, 1997). However, recent evidence suggests that working memory training can enhance fluid intelligence (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). These findings suggest that working memory training may be a useful strategy for reducing peoples' reliance stereotypes, but future studies will be necessary to test this possibility directly. Finally, most of our stereotyping tasks involved snap judgments of novel categories or unknown others. This approach likely negates some of the higher-order considerations that may work to decrease stereotyping in everyday social situations (e.g., relationship management). In the future, it will be interesting to compare stereotype processes among those with high and low pattern detection ability in diverse scenarios, including face-to-face encounters with known others.

Finally, the present studies relied on Mechanical Turk for sampling. Although numerous studies have shown that Mechanical Turk provides high-quality data that replicate classic psychological effects (Buhrmester et al., 2011; Paolacci et al., 2010; Paolacci & Chandler, 2014), the fact that our research involved tests of cognitive ability raises additional questions. For example, online participants may have performed poorly on both the stereotyping measure and the pattern detection test due to low motivation rather than low ability. A follow-up study suggested this was not the case, as the association between pattern recognition and stereotyping held when removing participants who failed an attention check. Other research further buttresses our findings, revealing that Mechanical Turk users perform as well as or better than student samples on fluid intelligence measures such as Raven's matrices (Buchheit, Dalton, Pollard, & Stinson, 2016). As with any study, it will be important to replicate these findings with diverse samples in the future. Appropriately large samples would also allow for fine-grained analysis of the interaction between target group membership and perceiver group membership, revealing whether pattern detection ability contributes to stereotyping equally for ingroup and outgroup members.

In summary, pattern detection ability plays an important and previously unrecognized role in stereotyping. Superior pattern detectors efficiently extract stereotypes from the behavior of social groups, and they activate and apply those stereotypes when evaluating novel group members. Superior pattern detectors also update their stereotypes on the basis of new information. Pattern detection therefore equips people with the cognitive skills necessary to be naïve empiricists, calibrating their beliefs to match incoming social knowledge. Although some people may develop "faulty and inflexible generalizations" about the behavior of social groups (Allport, 1954), those with superior cognitive abilities may have cognitive systems that are malleable enough to incorporate new information about the social groups they encounter on a regular basis.

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