Research Report

Motions of the Hand Expose the Partial and Parallel Activation of Stereotypes

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ABSTRACT—*Perceivers spontaneously sort other people's faces into social categories and activate the stereotype knowledge associated with those categories. In the work described here, participants, presented with sex-typical and sex-atypical faces (i.e., faces containing a mixture of male and female features), identified which of two gender stereotypes (one masculine and one feminine) was appropriate for the face. Meanwhile, their hand movements were measured by recording the streaming* x, y *coordinates of the computer mouse. As participants stereotyped sex-atypical faces, real-time motor responses exhibited a continuous spatial attraction toward the opposite-gender stereotype. These data provide evidence for the partial and parallel activation of stereotypes belonging to alternate social categories. Thus, perceptual cues of the face can trigger a graded mixture of simultaneously active stereotype knowledge tied to alternate social categories, and this mixture settles over time onto ultimate judgments.*

The act of stereotyping others has long been assumed to be a spontaneous economizing strategy used to simplify a bewildering amount of social information (Allport, 1954). Activating these stereotypes can mold our impressions of others (Fiske & Neuberg, 1990), distort our knowledge and memory of them (Bodenhausen, 1988), lead to unintended negative affect (Fazio, Jackson, Dunton, & Williams, 1995), and produce aggressive behavior (Bargh, Chen, & Burrows, 1996). The extensive aftermath of stereotype activation is, at this point, well documented.

Only somewhat recently, however, have researchers begun to explore the perceptual processes that culminate in stereotype activation. This growing body of person construal research (e.g., Cloutier, Mason, & Macrae, 2005), which aims to understand the processes lying between perceptual input and ultimate interpretations of others, has charted a clear sequence of events. When one catches sight of another's face, perceptual extraction of category-cuing information activates relevant social categories ("he's male"), which in turn engages knowledge structures that include associated stereotypes ("he's aggressive"). Stereotyping others thus involves the extraction of perceptual cues, which triggers a social category related to these cues, which triggers the stereotype knowledge tied to this social category, which is then finally applied to the target (e.g., Macrae & Bodenhausen, 2000; Mason, Cloutier, & Macrae, 2006).

Recent evidence suggests that these processing stages are continuous, and need not wait until one has completely finished before sending partially processed information onto the next. The *dynamic continuity account* of person construal (Freeman, Ambady, Rule, & Johnson, 2008), drawing on dynamical models in cognitive science (Spivey, 2007; Spivey & Dale, 2004, 2006), argues that each stage continuously cascades partial products of information processing seamlessly into the next. This account posits that, during the real-time accrual of perceptual information between, for instance, catching sight of another's face and recognizing that person's sex, partial output from visual extraction continuously updates a partially active category representation ("he's [tentatively] male"), and ongoing changes of that partially active category representation continuously update partially active stereotype knowledge ("he's [tentatively] aggressive"). This dynamic flux of tentatively available stereotype knowledge would then gradually stabilize onto particular interpretations of others.

If indeed such continuous dynamics underlie real-time stereotyping, it opens up the intriguing possibility that, when targets possess cues belonging to alternate social categories (e.g., a male with feminized features), a continuous competition between multiple partially active category representations may be triggered. If our theorizing is correct, this competition would instigate a fuzzy mélange of partial parallel activation of the

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stereotype contents of both the male category (e.g., "aggressive") and the female category (e.g., "caring").

Recent research has exploited on-line hand movements to index such partial parallel activation. By recording participants' computer mouse movements as they move the mouse into one of two response alternatives on the screen, parallel activation is revealed by the extent to which their movements are partially and simultaneously pulled toward one alternative as they make their way into the other. For example, a stimulus is centered at the bottom of the screen and two alternatives appear in the top left and right corners. As participants process the stimulus in real time, they move the mouse from the bottom center into one of the two corners. A mouse trajectory's continuous attraction toward the opposite alternative (on the opposite side of the screen) is evidence that that alternative was partially and simultaneously considered as participants nonetheless settled into their eventual interpretation.

Using this mouse-tracking technique, we previously found evidence for such partial parallel activation during basic sex categorization. When categorizing atypically sexed targets (e.g., a masculinized female), participants' mouse trajectories showed a continuous attraction toward the opposite sex category before stabilizing on the correct categorical response, indicating a temporally dynamic competition between partially active social category representations across construal (Freeman et al., 2008). This previous work suggests that category-cuing face information may trigger simultaneously and partially active category representations that gradually settle onto eventual categorical outcomes. Thus, on their way to arriving at a social categorization, perceivers can entertain a continuously evolving mixture of social categorical interpretations. What remains unclear is whether this mixture of parallel and partially active social categories computed during real-time construal may instigate parallel partial activation of the stereotype knowledge associated with those categories. That is, it is possible that partially active stereotype contents of alternate social categories could be instantiated simultaneously in response to another's face (e.g., for a masculinized female: "she's a bit caring and a bit aggressive"). Moreover, it is possible that perceptual cues tied to alternate social categories (e.g., masculinized cues on a female) could independently instigate parallel partial activation of stereotype knowledge. In the work described here, we tested this possibility.

METHOD

Participants

Twenty-four undergraduate students participated in exchange for partial course credit or $10.

Stimuli

To precisely manipulate sex typicality of the face and produce highly realistic faces, we used FaceGen Modeler to conduct morphing along sex, allowing us to seamlessly generate typical and atypical variants of the same target identity. Ten male faces were generated at the anthropometric male mean, and 10 female faces were generated at the female mean; together, these faces made up the typical condition. These same faces were then generated at a level 25% closer to the opposite-gender mean; these made up the atypical condition (see Fig. 1 for sample stimuli). For judgments, masculine and feminine stereotypes (e.g., aggressive or caring, respectively) were obtained from Crawford, Leynes, Mayhorn, and Bink (2004).

Procedure

Participants were told that, on every trial, a face would be presented with two adjectives, and that they were to identify which adjective was the stereotypically appropriate one for the face as quickly and accurately as possible. After participants clicked a start button centered at the bottom of the screen to initiate each trial, a random masculine stereotype and feminine stereotype appeared at the top left and right corners (which one appeared on the left and which one appeared on the right was randomized on every trial). After allowing participants to read these words for 2,000 ms, a target face replaced the start button, and the cursor was relocated to the bottom center. Participants "stereotyped" the target by mouse-clicking either the masculine or the feminine stereotype. Meanwhile, we recorded the streaming x, y coordinates of the computer mouse (sampling rate of approximately 70 Hz). To record, process, and analyze mouse trajectories, we used the MouseTracker software package, developed by the first author and freely available on the Web (http://mousetracker.jbfreeman.net). Details about the software and a discussion of analytic techniques for mouse trajectory data can be found in Freeman and Ambady (in press). To ensure mouse trajectories were on-line, we encouraged participants to begin initiating movement as early as possible. If initiation time exceeded 400 ms, a message appeared after participants made their response, informing them to start moving earlier on future trials even if they were not fully certain of a response.

RESULTS

All trajectories were rescaled into a standard coordinate space (top left: x, y = [−1, 1.5]; bottom right: x, y = [1, 0]). Because raw trajectories varied in duration (and thus how many time steps they contained), they were normalized into 101 time steps using linear interpolation to permit averaging of their full length across multiple trials. For comparison, all trajectories were remapped rightward. To obtain a trial-by-trial index of the degree to which the mouse was spatially attracted toward the opposite-gender stereotype (indicating how much that stereotype was simultaneously active), we computed maximum deviation (MD): the largest positive x-coordinate deviation from an ideal response trajectory (a straight line between the trajectory's start

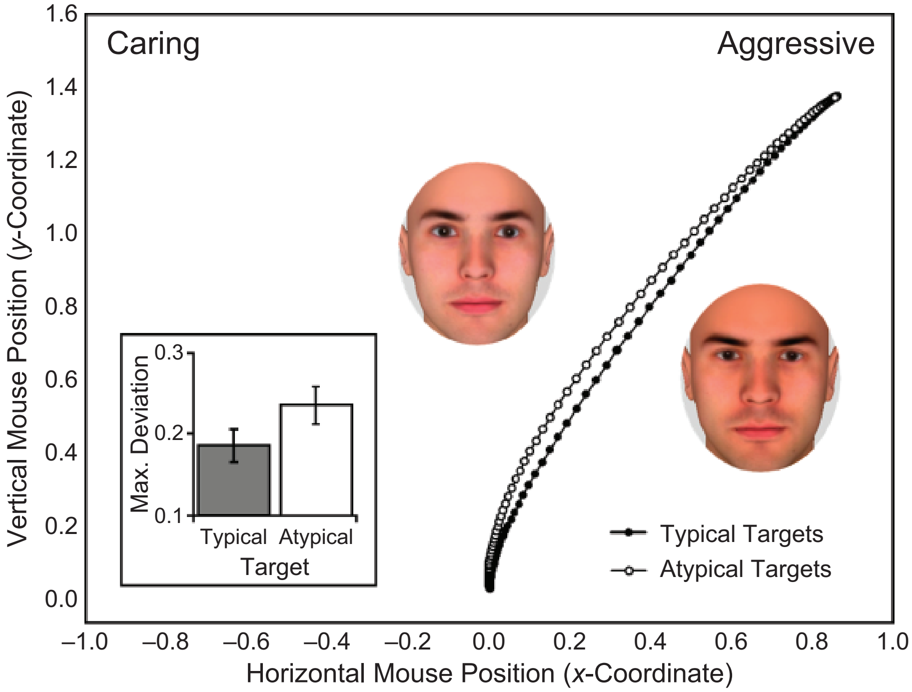

Fig. 1. Mean mouse trajectories in the experimental task (aggregated across male and female targets). The feminine- and masculine-stereotype labels appeared in the top left and right corners of the screen (*caring* and *aggressive*, shown here, are examples of the stereotype words that were displayed). In this figure, trajectories for all targets were remapped rightward, with the opposite-gender stereotype on the left and the stereotype label consistent with the target's gender on the right. Sample male face stimuli are also displayed. A typical male face is shown on the right, next to the mean trajectory for typical targets. Its atypical (feminized) counterpart is shown on the left, next to the mean trajectory for atypical targets. During an actual trial, a single face was centered at the bottom of the screen. The bar graph shows trajectories' maximum deviation toward the opposite-gender stereotype from a direct line between trajectories' start and end points, separately for typical and atypical targets (error bars denote standard errors of the mean).

and end points) out of all 101 time steps. Participants' gender did not influence performance.

Spatial Attraction

We computed a mean trajectory for typical targets and a mean trajectory for atypical targets. As evident in Figure 1, trajectories for atypical targets were continuously attracted to the opposite-gender stereotype, and this was statistically reliable: Indexed by MD, trajectories for atypical targets (M = 0.24, SE = 0.02) were more attracted toward the opposite stereotype relative to trajectories for typical targets (M = 0.19, SE = 0.02), $t(23) = 5.32$, $r = .742$, $p < .0001$.

To determine how this attraction effect evolved over time, we calculated, at every time step, the proximity of the mouse position to the opposite stereotype and plotted it across time (Fig. 2). Significant divergence of trajectories in the atypical condition toward the opposite stereotype (relative to trajectories for typical targets) would indicate that, at that time step, participants were partially attracted toward the opposite stereotype and thus partially and simultaneously entertaining that stereotypic interpretation. Thus, Figure 2 indexes the continuous flux of the opposite stereotype's partial activation across real-time stereotyping. Trajectories in the atypical condition began showing reliably more proximity to the opposite stereotype at the 10th time step ($p < .05$), and this divergence then gradually rose and fell over time. This reflects the gradual activation and settling of a partially active representation of the opposite-gender stereotype before participants stabilized onto ultimate judgments.

Distributional Analysis

Two alternative possibilities must be ruled out. One possibility is that the continuous-attraction effect could be the result of averaging together some trials showing zero attraction and other trials showing extreme discrete-like errors. If some atypical trials involved movement straight toward the selected stereotype and the remaining atypical trials involved movement straight toward the opposite stereotype, followed by a sharp midflight correction toward the selected stereotype, the mean trajectory would spuriously produce continuous attraction—when this continuous attraction would actually be due to several discrete-

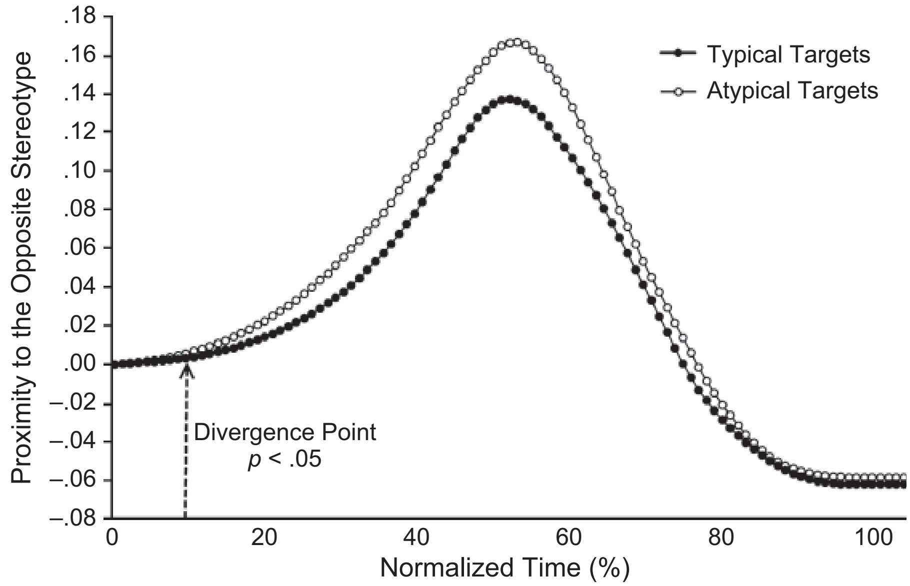

Fig. 2. Proportional euclidean proximity (1 − distance/maximum distance) to the opposite-gender stereotype as a function of normalized time, separately for typical and atypical targets. The dashed arrow indicates the point of significant divergence between trajectories for the two types of targets.

like errors biasing the results. We can detect this spurious pattern by examining the distribution of trial-by-trial attractions and inspecting for bimodality (for validation, see Study 3 of Freeman et al., 2008).

Another possibility is that, rather than results from categorization cascading continuously into the activation of stereotype knowledge, the categorization process could be gradual only to instantaneously arrive at (rather than continue flowing into) the discrete (rather than continuous) activation of stereotype knowledge. If true, however, the continuity of the categorization stage would cause trajectories for atypical targets to begin showing partial attraction toward the opposite alternative, but once resolved and stereotype knowledge is retrieved discretely, they would abruptly shift into discretely pursuing the selected stereotype. If all atypical targets elicited this pattern, it would be evidenced in their mean trajectory as an abrupt change in direction, which was not so (Figs. 1 and 2). If only some atypical targets elicited this pattern, inspecting the distribution of trial-by-trial attractions for bimodality would detect it.

Modality analysis of the distribution of MD values in the atypical condition confirmed that it was within the $b < 0.555$ bimodality-free region (SAS Institute, 1989), $b = 0.528$. Moreover, the Kolmogorov-Smirnov test verified that the shapes of the distribution for typical targets and distribution for atypical targets, once made equal mean and variance, were statistically indistinguishable ($D = 0.05$, $p = .61$). This ensured that the distribution for atypical targets was not selectively hosting latent bimodal features. That the attraction effect is unimodally distributed eliminates the two alternative possibilities described above, cementing our claim that it reflects multiple partially active stereotypes continuously evolving over time.

Control Task

To ensure that this attraction was due to the parallel activation of the opposite stereotype, rather than a more uncertain or less decisive movement toward the selected stereotype, we conducted an additional control study in a small group of participants ($N = 12$). The same trials as in the main experiment were presented, except that an appropriate gender stereotype and a food-related control word (e.g., *sugary*) appeared in the top left and right corners of the screen. Trials with food images (e.g., apple) were presented as fillers. Participants also completed identical trials of the main task. If the attraction effect was due to a less decisive movement toward the selected stereotype, it should persist regardless of the opposite alternative. However, if the attraction effect was due to a genuine pull toward the opposite-gender stereotype, the effect should disappear when the opposite alternative is not that stereotype.

Figure 3 depicts the mean trajectories of this control task. On trials where the other alternative was a food-related word, the MD of trajectories in the typical and atypical conditions did not differ, $t(11) = 1.06$, n.s., and the mean trajectories completely overlapped (Fig. 3). On trials where the other alternative was the opposite-gender stereotype, however, the attraction effect was replicated, with trajectories in the atypical condition more attracted to the opposite stereotype than those in the typical condition, $t(11) = 2.21$, $p < .05$. We conclude that the attraction toward the opposite stereotype in the atypical condition is due to

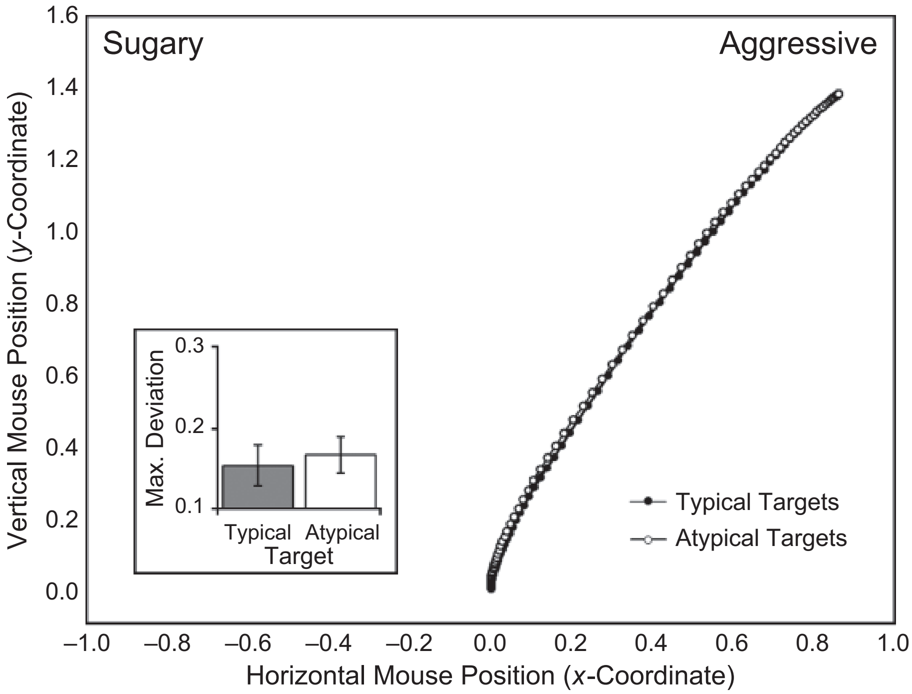

Fig. 3. Mean mouse trajectories in the control task. The food-related control word and stereotype label appeared in the top left and right corners of the screen (*sugary* and *aggressive*, shown here, are examples of the words that were displayed). In this figure, trajectories for all targets were remapped rightward, with the food-related control word on the left and the stereotype label on the right. The bar graph shows trajectories' maximum deviation toward the food-related control word from a direct line between trajectories' start and end points, separately for typical and atypical targets (error bars denote standard errors of the mean).

the parallel activation of that stereotype rather than a less decisive movement toward the selected stereotype.

DISCUSSION

We found that atypically sexed targets (containing overlapping male and female cues) triggered simultaneously and partially active stereotype contents belonging to alternate social categories. This was supported by evidence showing that, when stereotyping these atypical targets, participants' real-time motor trajectories exhibited a continuous attraction toward the opposite-gender stereotype before stabilizing on eventual interpretations. Thus, multiple cues of the face tied to alternate social categories can trigger partial parallel activation of the stereotype knowledge associated with those categories.

Although participants' attraction toward the opposite-gender stereotype "stops" with their ultimate mouse-click, this is unlikely to be the end of that stereotype's partial activation. The attraction effect we report is evidence that an opposite-gender stereotype is simultaneously and partially active across person processing, and social psychologists have long documented the lasting consequences of a stereotype activation—even the briefest of kinds (e.g., priming)—on social judgment, interaction, and behavior (Macrae & Bodenhausen, 2000). It is thus reasonable to suspect that the partial and parallel activation of stereotypes (e.g., *aggressive* for a masculinized female) may bear a variety of unforeseen downstream consequences.

These data help account for—and also provoke new questions about—recent findings of exemplar typicality and face variation effects on stereotype activation and social judgment (e.g., Blair, Judd, Sadler, & Jenkins, 2002; Livingston & Brewer, 2002; Locke, Macrae, & Eaton, 2005). Specifically, these findings provide a novel demonstration of how variation of category-cuing information biases the real-time stereotyping process in a continuous and graded way. They also show how subtly overlapping features between different social categories (e.g., male and female) may trigger a graded blending of partial parallel activations of the stereotype knowledge associated with those categories. These simultaneously and partially active stereotypes, triggered by multiple perceptual cues, may then dynamically compete to settle on ultimate judgments of others. Thus, we provide insights into the complex, dynamic nature of stereotypic thinking, showing how perceptual cues can evoke simultaneously and partially active stereotype knowledge that continuously fluctuates over time.

This evidence, more broadly, suggests that a dynamic approach to mental processing—seeing perception, cognition, and action as continuously changing in real-time and mutually interacting in a self-organizing dynamic biological system (e.g., Kelso, 1995; Port & van Gelder, 1995; Spivey, 2007; Spivey &

Dale, 2004)—is key for making novel insights about a variety of psychological phenomena. Researchers have looked to real-time hand movements, as we did here using mouse tracking, to flesh out the interactive and continuously evolving nature of mental processes. Such work has found evidence for the continuous dynamics in spoken language processing (Spivey, Grosjean, & Knoblich, 2005), semantic categorization (Dale, Kehoe, & Spivey, 2007), and visual search (Song & Nakayama, 2008), among others (Spivey, 2007). We believe that a dynamic approach to social perception and cognition could be similarly insightful (e.g., Freeman et al., 2008).

In sum, we show how simultaneously and partially active stereotype knowledge is triggered across ongoing perceptual accrual, settling over time onto our ultimate judgments of others. By examining motions of the hand, we have revealed the partial and parallel activation of stereotypes tied to alternate social categories.

Acknowledgments—This research was funded by National Science Foundation Research Grant NSF BCS-0435547 (to N.A.). We thank Jasmin Cloutier and Rick Dale for helpful discussion.

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(Received 12/17/08; Revision accepted 3/12/09)