



Reports

Resource-dependent effects during sex categorization

L. Omar Rivera, Clarissa J. Arms-Chavez, Michael A. Zárate *

Department of Psychology, University of Texas at El Paso, El Paso, TX 79968, United States

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ABSTRACT

The limited capacity of face perception resources in the left cerebral hemisphere was examined using a sex categorization task. One study tested the hypothesis that sex categorization is impeded whenever feature extraction resources in the left hemisphere are simultaneously being utilized by another task. This hypothesis was tested by presenting prime faces for either 32 ms or 320 ms to either the left or right visual-field just before centrally presented target faces were categorized by sex. Results showed that sex categorization was slower after prime faces were presented for 32 ms in the right visual-field compared to the left visual-field. This difference was not found after the 320 ms prime length. The results are interpreted in the context of a neurocognitive model of social perception and suggest that efficient sex categorization depends, in part, on the availability of facial feature extraction resources in the left hemisphere.

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Our interactions with others are influenced by our initial perceptions of them. When we encounter others, much of our attention is directed towards the face. Faces capture a disproportionate amount of our attention compared to other visual stimuli (Bindemann, Burton, Hooge, Jenkins, & de Haan, 2005). Thus, the current research focuses on face perception as an initial step in social information processing. It builds on a neurocognitive model of social perception in which distinct face-processing strategies give rise to distinct social representations (Zárate, Sanders, & Garza, 2000). The model contends that resources associated with these strategies are distributed across the cerebral hemispheres and are limited in capacity. The current research examines how the limited-capacity of these resources influences social categorization.

Cerebral asymmetries in social perception

Zárate et al.'s (2000) neurocognitive model of social perception maintains that processing asymmetries across the cerebral hemispheres underlie conceptually distinct social cognitive phenomena. This model accounts for social categorization and social individuation by hypothesizing that each phenomenon is driven by the distinct processing strategies that are distributed across the cerebral hemispheres. Left hemisphere (LH) processes identify the category membership features of others more efficiently and therefore facilitate social categorization. Right hemisphere (RH) processes integrate the individuating characteristics of others more efficiently

and therefore facilitate social individuation. These processes work in parallel to produce various dissociations between group- and person-based social perception (Sanders, McClure, & Zárate, 2004; Zárate, Stoeber, Maclin, & Arms-Chavez, 2008).

This model derives from feature versus configural processing distinctions identified in the neurocognitive literature on face perception. Facial features (e.g., eyes, nose, mouth) and their specific arrangement or spatial configuration on a face are central to models of face perception (Cabeza & Kato, 2000; Farah, Wilson, Drain, & Tanaka, 1998). Processes that encode specific facial features are differentiated from processes that encode spatial configurations of facial features. Feature encoding processes permit the categorization of faces along social categorical dimensions (e.g., race) (Levin, 1996; Schyns, Bonnar, & Gosselin, 2002). Configural encoding processes permit the identification of faces as particular individuals (Leder & Bruce, 2000; Yin, 1969).

These distinct encoding strategies are distinguished by the cerebral hemispheres. The LH is more attentive to specific facial features than to configurations of features (Scott & Nelson, 2006). It mediates categorical visual processes that are sensitive to similarities between other-race faces (Golby, Gabrieli, Chiao, & Eberhardt, 2001). The RH is more attentive to configurations of features than to specific features (Scott & Nelson, 2006). It mediates coordinate visual processes that are sensitive to differences between own-race faces (Golby et al., 2001). In summary, the encoding of specific facial features permits social categorization of an individual and the LH is more adept at feature encoding. The integration of facial features into a feature configuration permits identification of an individual and the RH is more adept at configural encoding.

Further support for the neurocognitive model of social perception has been demonstrated using unilateral visual-field presenta-

* Corresponding author.

E-mail addresses: LORivera@miners.utep.edu (L.O. Rivera), mzarate@utep.edu (M.A. Zárate).

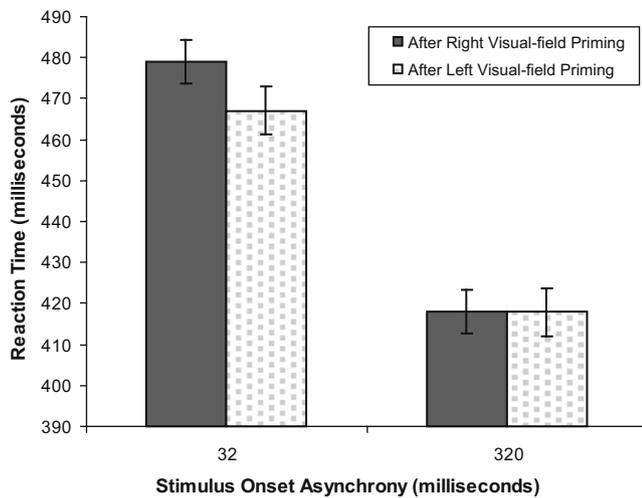


Fig. 1. Mean response latencies for sex categorization as a function of visual-field priming and stimulus onset asynchrony.

tion techniques. These techniques involve the presentation of stimuli to the left or right of a central fixation point. Stimuli that are presented to the left of a fixation point or left visual-field (LVF) are initially processed in the RH, whereas stimuli that are presented to the right of a fixation point or right visual-field (RVF) are initially processed in the LH. Subsequent task performance is reflective of left or right hemisphere processing efficiency (Kim, Levine, & Kertesz, 1990).

Various studies have used visual-field techniques in combination with reaction time (RT) measures (Zárate & Sanders, 2004; Zárate et al., 2000) and galvanic skin response measures (Sanders et al., 2004) to test the neurocognitive model of social perception. These studies show that conceptually distinct social cognitive phenomena are moderated by processing differences across the cerebral hemispheres. For instance, our memory for a target group is superior in the LH, whereas our memory for a specific target is superior in the RH (Zárate et al., 2000). In addition, social category priming effects are more pronounced in the LH, whereas individual similarity priming effects are more pronounced in the RH (Zárate et al., 2000). Furthermore, classically conditioned responses to a target group are more efficiently developed in the LH, whereas classically conditioned responses to a specific target are more efficiently developed in the RH (Sanders et al., 2004). Collectively, the LH consistently responds to social stimuli at the group level, whereas the RH consistently responds to social stimuli at the person level.

When we encounter others, both hemispheres simultaneously begin to extract facial information. The LH extracts facial feature information that can then be used to categorize others along social categorical dimensions. The RH extracts facial feature configurations that can then be used to identify specific people. Previous research suggests that the processing strategy that dominates during the initial encoding ultimately influences our perception of others (Zárate et al., 2008). Thus, a disruption in the processing strategy that dominates during initial encoding should disrupt the associated social perceptions. For example, if the LH's ability to extract specific facial features is disrupted, ensuing social categorization processes should be impeded. The ability to impede social categorization is important because of the automaticity with which social categorization activates stereotypical information that can negatively influence social interactions (Brewer, 1988; Dovidio, Evans, & Tyler, 1986; Fazio & Dunton, 1997; Zárate & Smith, 1990).

The research presented here examines how social categorization is influenced by the availability of hemispherically distinct processing resources. Our hypothesis is derived from multiple resource theory (MRT). MRT contends that distinct limited-capacity processing resources exist and are distributed across the cerebral hemispheres. These processing resources are differentially recruited to complete any one task (Boles & Law, 1998; Wickens, 1992, 2002). MRT predicts that task performance will suffer whenever two consecutively presented tasks recruit the same resources. The current research tests the hypothesis that distinct face-processing resources are distributed across the cerebral hemispheres and have a limited processing capacity. The extraction of facial information is assumed to take time and occur in a serial fashion. While information is being extracted, subsequent requests for information extraction (e.g., encountering another face) are delayed until the existing information extraction process is complete. Once facial information extraction begins, the efficiency with which the system can extract subsequent facial information depends on how temporally close subsequent facial information is presented. If subsequent facial information is presented before initial facial information has been extracted, subsequent facial information extraction will be disrupted.

Research on perceptual and conceptual masking suggests how temporally close subsequent stimulus information should be presented in order to interfere with initial stimulus information extraction. Loftus and Ginn (1984) demonstrate that perceptual information extraction is not complete within the first 50 ms of stimulus onset but is complete after the first 300 ms of stimulus onset. Thus, in the current research, we manipulated prime–target stimulus onset asynchrony (SOA). One SOA was set below the amount of time required for perceptual information extraction from the prime to complete (32 ms) and another was set above the amount of time required for perceptual information extraction from the prime to complete (320 ms).

Because the LH is more efficient at feature extraction, it is predicted that when a prime face is presented in the RVF–LH for less than the amount of time it takes to extract perceptual information from it (32 ms), participants will be slower to categorize a subsequent centrally presented target face by sex than when a prime face is presented in the LVF–RH. This is because feature extraction resources in the LH will not have completed extracting facial feature information in the prime face by the time the target face requests the same resources. Yet when a prime face is presented in either the RVF–LH or LVF–RH for longer than the amount of time it takes to extract perceptual information from it (320 ms), subsequent centrally presented face categorization times are expected to be similar. These times are expected to be similar because both hemispheres are capable of extracting facial feature information within 320 ms. Thus, feature extraction from either a LVF–RH or RVF–LH prime face will be complete by the time a target face requests the same resources. Both prime lengths (30 ms and 320 ms) are fast compared to most priming studies, reducing any conscious decision making strategies (Neely, 1976). Thus, any priming or inhibitory effects are theorized to be due to perceptual processing mechanisms.

Overview

A sex categorization task was employed within a divided visual-field methodology. Participants used a response pad to categorize centrally presented target photos of Mexican-American males and females by sex. Prior to categorizing each target photo, a prime photo (either a Mexican-American male or female) was briefly presented to either the RVF–LH or LVF–RH with either a 32 ms or 320 ms SOA between prime and target photos. RTs to target photo categorizations were recorded.

Method

Participants

Fifty-seven (32 female, 20 male, five not reported) undergraduates were recruited from Introduction to Psychology courses. Forty-two participants were self-reported Mexican-American. The remaining participants were Mexican-Nationals ($n = 7$), Anglo-Americans ($n = 5$), and other ethnic group members ($n = 3$). The average participant age was 19 years ($SD = 5.07$ years) with a range of 17–35 years. All participants received partial course credit for their participation.

Materials

The categorization task was programmed on SuperLab 2.0 software (Cedrus Corporation, 2002). Participants responded via a Cedrus RB-820 response pad. A chin rest kept participants' eyes stable at a distance of 53 cm from a 17-in computer monitor with a refresh rate of 8 ms. Photos included 128 head and shoulder color photos of Mexican-American male (64) and female (64) college students in a frontal pose. Each photo was approximately 6.5 cm by 7.5 cm at 72 dpi. Sixty-four photos (32 male and 32 female) served as primes and the other 64 served as targets. Participant handedness was not assessed because similar experiments in our lab have repeatedly failed to show handedness effects.

Design and procedure

The experimental design was a 2 (Prime–Target Sex Match: same or different) \times 2 (Visual-field of Prime: left or right) \times 2 (SOA: 32 ms or 320 ms) \times 2 (Target Response Order: male first or female first) \times 2 (Participant Sex) mixed design ANOVA, with RT as the dependent variable. The first three factors were within-subjects and the last two factors were between-subjects.

Participants responded to a total of 64 trials. All photos were presented only once throughout the experiment, as either a prime or a target. There were 16 trials of each of the following prime/target combinations: female prime/female target, male prime/male target, female prime/male target, and male prime/female target. Each trial consisted of (a) a 2 s blank screen, (b) a central fixation cross that blinked for 3 s, and (c) a 32 ms (1/2 of all trials) or 320 ms (1/2 of all trials) unilaterally presented prime photo that was immediately followed by (d) a 1500 ms centrally presented target photo. The central fixation cross blinked at an increasing rate throughout the 3 s that it was presented. Prime presentation rates (32 ms or 320 ms) were randomized throughout the study. Prime photo presentation rates were a function of the 8 ms computer monitor refresh rate. The center of each prime photo was either 6.5 cm to the left or right of the central fixation cross.

Participants categorized target photos by sex as quickly as possible by pressing a response button with either index finger. They were told to ignore prime photos as they were included to measure participant distractibility. A go/no-go procedure (White, 1981) required participants to respond to the first half of the trials only if the target photo was a female and to the second half of the trials only if the target photo was a male. The order in which participants responded to female and male targets was counterbalanced across participants. The go/no-go procedure was used to reduce response competition and interhemispheric communication. Experimental sessions lasted approximately 15 min.

Results

RT data from two participants (one Mexican-National male, one other male) were excluded from analyses because they failed to

keep their chin on the chin rest. Analyses were conducted on data from the resulting participants ($n = 55$).

The overall analysis revealed that Prime–Target Sex Match, Target Response Order, and Participant Sex had no effects on RTs and these factors were dropped from subsequent analyses. The resulting 2-way ANOVA revealed a significant effect of SOA. Sex categorization took significantly longer after 32 ms primes ($M = 473$ ms, $SD = 64$ ms) than after 320 ms primes ($M = 418$ ms, $SD = 69$ ms), $F(1, 54) = 127.97$, $p < 0.001$. This effect was qualified by a Visual-field of Prime \times SOA interaction, $F(1, 54) = 3.98$, $p = 0.05$, $d = 0.17$. To test our hypothesis, this interaction was analyzed separately at each SOA. At 32 ms SOAs, participants categorized targets slower after primes were presented in the RVF–LH ($M = 479$ ms, $SD = 65$ ms) than after primes were presented in the LVF–RH ($M = 467$ ms, $SD = 69$ ms), $F(1, 54) = 6.52$, $p = 0.01$, $d = 0.18$. At 320 ms SOAs, participants categorized targets with equal speed regardless of whether primes were presented in the RVF–LH ($M = 418$ ms, $SD = 67$ ms) or LVF–RH ($M = 418$ ms, $SD = 74$ ms) (see Fig. 1). These results support our hypothesis that while the LH is busy extracting face information from a prime face, subsequent tasks that rely on those resources are impeded. Yet when the LH is given enough time to finish extracting face information, subsequent tasks that rely on those resources are completed with relative efficiency.

Discussion

The current research supports the hypothesis that the efficiency with which one can categorize faces by sex depends on the availability of processing resources in the LH. Specifically, one's ability to categorize a face by sex is impeded whenever face perception resources in the LH are being utilized by other tasks. When LH feature extraction resources are not given enough time to extract information from an initially encountered face, categorization of a subsequently encountered face takes longer than when these same resources are given enough time to extract this information.

In the context of the neurocognitive model of social perception (Zárate et al., 2000), the current research suggests that social perception is influenced by the availability of distinct and limited-capacity resources that are distributed across the cerebral hemispheres. Social perception is not only driven by the feature identification and feature integration strategies employed by the left and right hemispheres (Sanders et al., 2004; Zárate & Sanders, 2004; Zárate et al., 2008), it is also driven by the availability of resources associated with these strategies. When feature extraction resources in the LH are not exclusively available to process incoming social information, group-based social perception is less efficient. We suspect that a similar resource-dependent effect will be observed in the RH, albeit with respect to person-based social perception.

The availability of LH perceptual processing resources also influences whether or not sex category priming effects emerge. Sex category priming effects have been observed in previous research by manipulating the match between prime and target sex during a sex categorization task. Sex category priming occurs when a match between prime and target sex facilitates target sex categorization. Zárate et al. (2000, Experiment 3) demonstrated that this type of priming was most pronounced in the LH. Yet in the current research, a match between the sex of RVF–LH primes and target faces did not facilitate target sex categorization times. We suspect that sex category priming effects were not observed in the current research because of the short prime-to-target SOAs. The short SOAs were intended to initiate a processing bottleneck at the perceptual processing stage, before gender information had been abstracted. Thus, incomplete feature extraction from prime faces prevented

the identification of prime sex, which in turn prevents the activation of the semantic associations that are generally responsible for social category priming effects (Martin & Macrae, 2007).

Knowledge about the influence of resource limitations on social perception allows us to test hypotheses about the interaction of group- and person-based perceptual processes. According to the neurocognitive model of social perception, both hemispheres initiate their respective processing strategies as soon as social information is encountered. The type of social perception that ultimately ensues depends on the processing strategy that dominates during the initial encoding (Zarate et al., 2008). If the LH strategy (i.e., feature identification) dominates, the ensuing social representation is primarily group-based. On the other hand, if the RH strategy dominates (i.e., feature integration), the ensuing social representation is primarily person-based. One factor that may influence the strategy that dominates is the availability of specific resources. The logic behind this is similar to the logic that underlies research on inter-hemispheric inhibition by unilateral suppression (Banich & Belger, 1990; Chiarello & Maxfield, 1996; Davidson, Cave, & Sellner, 2000; Liederman & Meehan, 1986; Querné, Eustache, & Faure, 2000; Weissman & Banich, 1999, 2000). This research suggests that when requests for resources in a particular hemisphere exceed the availability of resources in that hemisphere, corresponding processes in the opposite hemisphere are recruited. Thus, the unavailability of feature identification resources in the LH should provide an opportunity for feature integration resources in the RH to dominate the initial encoding. This should in turn facilitate person-based social perception. Ultimately, this leads to the prediction that less efficient group-based social perception should be observed simultaneously with more efficient person-based social perception, and vice-versa.

Our results are generally consistent with the view that social categorization depends on the availability of resources. In contrast to the view that social categorization drives perception when cognitive resources are low, Spears, Haslam, and Jansen (1999) demonstrated that social categorization depends on the availability of cognitive resources (see also Gilbert & Hixon, 1991). Because social categorization is dependent on cognitive resources, it can be hindered via a cognitive load (Spears & Haslam, 1997). To make this argument, Spears and colleagues used a variation of the “who said what” paradigm (Taylor, Fiske, Etcoff, & Ruderman, 1978), presented under varying amounts of cognitive load. Cognitive load was manipulated by varying the time given to process several to-be-recalled statements made by male and female individuals (Experiment 2). Social categorization was indexed as the difference of within-sex minus between-sex errors, with lower numbers indicating less use of sex as an organizing category. In general, as cognitive load increased, the difference of within-sex minus between-sex errors decreased. This suggests that social categorization by sex generally diminishes as cognitive load increases.

Our results also extend this view by demonstrating that the loading of LH resources in particular produces less efficient sex categorization. Although our briefly presented (32 ms) RVF–LH primes may be better characterized as perceptual loads (Bindemann, Burton, & Jenkins, 2005; Lavie, Ro, & Russell, 2003), they functioned similarly to cognitive loads. Specifically, RVF–LH primes slowed central target sex categorization. This suggests that resource loads do not function uniformly across the hemispheres. LH loads are more detrimental to social categorization processes than are RH loads. Future research efforts should examine the specificity with which face-processing resources can be targeted using simple tasks that load LH feature extraction resources versus RH feature integration resources during a social encounter.

Finally, although we did not examine stereotyping in the current research, we believe that resource depletion during the perceptual processing stages of social categorization has

implications for stereotype activation. A variety of research suggests that the mere categorization of a person into a social group activates associated stereotypes (Bargh, 1999; Devine, 1989; Dovidio et al., 1986; Fazio & Dunton, 1997), which can influence social interaction under certain circumstances (Kunda & Spencer, 2003; Zarate & Smith, 1990). Given that LH resource depletion interferes with the categorization of a person into a social group, we suspect that resource depletion will ultimately interfere with stereotype activation. Our suspicion is generally consistent with Gilbert and Hixon's (1991) research showing that resource depletion inhibits stereotype activation. Here we extend this research by suggesting that LH resource depletion will be particularly detrimental to stereotype activation.

Conclusion

Social information processing resources are distributed across the hemispheres and are sensitive to processing demands. When processing demands exceed capacity, social information processing is disrupted. The existence of distributed limited-capacity resources has implications for models of social perception. Selectively exceeding the capacity of social information processing resources in the LH interferes with social categorization. Future social cognitive models should more clearly disentangle the specific processing resources necessary to complete any particular social perception task in order to fully understand how distinct processing resources contribute to social perception. Understanding the limitations of these resources will improve our ability to predict distinct social cognitive phenomena.

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