Motherhood Modulates Cognitive Biases Toward Family Members: the Maternal Self-concept Re-examined Through Categorization Tasks

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Abstract

The self-bias is a robust effect where self-related information is processed with greater priority than other-related information. Interestingly, the advantages of self-bias can be extended to close others – faster and more accurate responses for one's mother and best friend have been observed compared to strangers – suggesting that significant others play an important role in the formation of one's self-concept. Moreover, important life experiences such as childbirth can also impact the self-concept. Motherhood is a major transformation for women as one prepares to become a mother while maintaining the integrity of the pre-pregnant self-concept to achieve an ideal maternal self. The current study explored how the transition into motherhood changes the self-concept and subsequently impact the categorization of information for family members in postpartum mothers. In two experiments, results consistently revealed biases towards the self and close kin (one's baby and mother) regardless of stimulus type (names in Experiment 1, faces in Experiment 2) and response category (self/other, family/non-family, familiar/non-familiar). A family bias (for baby and mother) over friend was observed in the family/non-family but not in the familiar/non-familiar categorization task, suggesting that motherhood may enhance the boundary between family and non-family to facilitate the processing of family-related information.

Introduction

Previous research has found both faster reaction times and higher accuracy in response to self-related stimuli than stimuli associated with others. This prioritization of self-related processing has been referred to as the self-bias effect. This effect has been observed in many areas of cognitive research. For example, there is often better performance in response to one's own face and name than faces and names of others\textsuperscript{1-4}. Memory recognition and recall are remarkably accurate when the items were encoded in relation to the self\textsuperscript{5-9}. Self-related stimuli attracts so much attention that it can hurt performance when they are presented as distractors than other stimuli in both visual and acoustic studies\textsuperscript{10-13}.

The self-bias effect may serve an evolutionary purpose in that the self-concept has been developed with experience to enhance the adaptive fitness of the self when encountering new stimuli or novel situations\textsuperscript{14}. In other words, the ability to identify and prioritize self-related information through the activation of self-concept can maximize personal goals by enhancing individual survival and facilitating the decision-making process. Moreover, the development of automatic and improved perceptual capacities through the established self-concept is important to allow rapid mental registration of an accurate account of the stimuli\textsuperscript{15}. This is crucial because new stimuli that do not fit into pre-existing conceptual categories can hinder rapid response. Consequently, faster responses to highly self-relevant stimuli and the improved perceptual capacity for novel stimuli are essential to survival in novel environments. This means that the bias toward self-related stimuli is plausibly an instinct embedded through evolution.

Despite the robustness of the self-bias effect, the self is a dynamic concept which adapts to the changing environment\textsuperscript{16-18} and the construction of one's self concept is heavily dependent on one's
relationship with close family members and friends\textsuperscript{19,20}. Indeed, stimuli of close others such as kin and close non-kin (friends) elicit weaker self-bias than non-kin (strangers), where responses to stimuli relevant to close others were faster and more accurate than stranger stimuli\textsuperscript{21,22}. These findings confirm that the self is a dynamic concept modulated by social factors such as context and experiences.

Becoming a mother is an important life change for women as one's self-concept shifts to assume the maternal role. During pregnancy, the self-concept undergoes significant transformations in order to achieve an ideal maternal self. This transition into motherhood requires changes in behaviors and responsibilities that restructures the self-concept\textsuperscript{23}. Mothers must adapt to the new reality while still maintaining the integrity of the self by integrating the ideal image of the self as a mother with the pre-pregnant self\textsuperscript{24,25}. Thus, one's self-concept changes significantly as a result of motherhood.

From an evolutionary perspective, the survival of the offspring is dependent on parental care and the protection of one's children\textsuperscript{26,27}. Differentiating kin from non-kin is a survival instinct resulted from living in social groups\textsuperscript{28,29}. This is particularly important due to competition over resources and territories with members of the outgroup\textsuperscript{30}. Findings indicated that when under threat, increased activation of the caregiving system resulted in increased bias against outgroups, while the absence of threat resulted in decreased negative attitudes toward outgroups\textsuperscript{31}. Thus, the ability to categorize people into membership groups to prioritize for the distribution of resources and enhance survival plays an important role in self-related processing.

However, the need for competition over resources and territories, and other threats for survival, have decreased dramatically compared to prehistoric times. This means that there is less need for negative attitudes towards outgroups and the ability to differentiate kin from non-kin, especially for friendly non-kin such as close friends, may become unnecessary. Under these circumstances, the development of social categorization may hinder response towards close non-kin. Moreover, close others such as baby, mother and friends all play an important role in one's construction of the self concept\textsuperscript{32}. Activations in the medial prefrontal cortex (MPFC), which has been observed to reflect the activation of internal self-representations\textsuperscript{33,34}, were found for both self and family members (i.e. self, spouse, offspring) but not for non-family member\textsuperscript{35}. This indicated that close kin share similar neural representations with the self. Thus, understanding the categorization process for close others is crucial to understanding self-related processing during motherhood.

In line with these ideas, the current study was designed to 1) explore the impact of motherhood on the stability of the self-concept under categorization processes and 2) investigate the impact of motherhood on the categorization of information for significant others such as one's baby and one's mother in relation to more distant others (Fig. 1). Faces and names two well-established information regarding the self and others - were used as stimuli to test whether the effects were robust enough for replication with different kinds of stimuli (Fig. 2). In each experiment, participants were asked to respond by categorizing the name/face stimulus into its corresponding group – self versus others, family versus non-family, and
familiar versus non-familiar (Fig. 1 and 2). Experiment 1 categorized names of self, baby, mother, a best friend, the experimenter, and a stranger into self or others (Experiment 1a), family or non-family (Experiment 1b), and familiar or non-familiar (Experiment 1c). The experimenter, as a stimulus, was used to test whether a relatively familiar stranger, as opposed to complete stranger, would influence the self-bias effect. Experiment 2 used faces as stimuli, but due to difficulties obtaining photos of faces ahead of time, only faces of self, baby, stranger baby, and stranger woman were used to study categorization for self or other (Experiment 2a), and family or non-family (Experiment 2b).

Data were analyzed by 1) making comparisons between the self stimulus and each of the other stimulus conditions to examine the response differences in reaction times and accuracy; 2) comparing the response differences between group categories (self versus others, family versus non-family, and familiar versus non-familiar), which was calculated by averaging the corresponding stimulus conditions. Due to the robustness of the self-bias effect, the self stimulus condition was excluded in the family/non-family and familiar/non-familiar group categories to avoid results being driven by self-bias. Moreover, analyzing the results without the self stimulus condition would also further our understanding of how kin (baby, mother) and close non-kin (friends) are perceived compared with strangers.

Results

Experiment 1: Categorization of Name Stimuli

Experiment 1a: Self vs. Others Categorization

Reaction Times A repeated measures ANOVA on the reaction times (RTs) revealed a significant main effect of name stimuli, $F(5, 145) = 9.33, p < .001, \eta_p^2 = .24$ (Table 1). Paired-samples t-tests performed on the self and other name stimuli found significant slower responses to the baby name, $t(29) = -4.42, p < .001, dz = .54$, and mother name, $t(29) = -5.33, p < .001, dz = .66$, compared to self-name (Fig. 3). In contrast, no significant differences were found between self and friend name, $t(29) = -1.38, p = .178, dz = .18$, self and experimenter name, $t(29) = -.82, p = .418, dz = .11$, nor between self and stranger name, $t(29) = -2.06, p = .049, dz = .22$. This demonstrated that the participants needed more time to identify the baby and mother names as not belonging to the self, whilst friend, experimenter and stranger names were identified much easier as not-self.
| Name Stimulus | Experiment 1a: Self/Other | Experiment 1b: Family/Non-Family | Experiment 1c: Familiar/Non-Familiar |
|---------------|--------------------------|-------------------------------|-----------------------------------|
|               | RTs          | ACC   | RTs          | ACC   | RTs          | ACC   |
| Self          | 474 (61)    | .95 (.04) | 520 (63)    | .97 (.04) | 491 (62)    | .98 (.05) |
| Baby          | 510 (71)    | .92 (.10) | 552 (67)    | .95 (.05) | 528 (58)    | .96 (.06) |
| Mother        | 518 (71)    | .93 (.09) | 563 (65)    | .92 (.08) | 532 (70)    | .94 (.09) |
| Friend        | 485 (63)    | .98 (.04) | 630 (78)    | .82 (.14) | 565 (53)    | .90 (.12) |
| Experimenter  | 480 (52)    | .98 (.05) | 556 (74)    | .97 (.05) | 547 (63)    | .94 (.06) |
| Stranger      | 487 (56)    | .98 (.05) | 552 (64)    | .98 (.03) | 547 (64)    | .92 (.09) |

Table 1. Mean RTs (ms) and ACC (with SDs in brackets) as a function of name stimuli for Experiments 1a, 1b, 1c.

Group comparisons demonstrated significantly faster responses to self-name than all other name stimulus conditions combined (calculated using baby, mother, friend, experimenter, stranger), $t(29) = -3.91, p = .001, dz = .38$ (Fig. 4). However, further analyses revealed that this difference was mostly driven by the significantly slower responses for baby and mother names.

Accuracy Accuracy was calculated and analyzed in consistency with RTs results. Analyses on the accuracy showed a significant main effect of name stimuli, $F(5, 145) = 6.47, p < .001, \eta^2_p = .18$ (Table 1). Accuracy for self name was significantly lower than for friend, $t(29) = -4.06, p < .001, dz = .63$, experimenter, $t(29) = -3.59, p = .001, dz = .82$, and stranger names, $t(29) = -2.87, p = .008, dz = .55$ (Figure 3). Accuracy for self-name was not significantly different from baby name, $t(29) = 1.90, p = .068, dz = .42$, and mother name, $t(29) = 1.05, p = .300, dz = .22$.

Group comparisons found that accuracy for self-name stimulus was not significantly different from names of others (calculated using baby, mother, friend, experimenter, stranger), $t(29) = -.79, p = .44, dz = .16$ (Figure 4).

Experiment 1b: Family vs. Non-Family Categorization

Reaction Times A repeated measures ANOVA revealed a significant main effect of name stimuli, $F(5, 145) = 24.65, p < .001, \eta^2_p = .46$ (Table 1). Given that the main focus of this study was to look at the changes in self-concept in relation to others through information categorization, paired samples t-tests were only performed in comparison to the self. Consistent with the self-bias effect, responses to the self-name were significantly faster in comparison to baby, $t(29) = -3.15, p = .004, dz = .49$, mother, $t(29) = -4.34, p < .001, dz = .67$, friend, $t(29) = -10.18, p < .001, dz = 1.54$, experimenter, $t(29) = -3.59, p = .001, dz = .52$, and stranger name, $t(29) = -4.04, p < .001, dz = .50$ (Figure 3).
A group comparison between family members (calculated using baby and mother) and non-family members (calculated using friend, experimenter and stranger) also revealed significantly faster responses to family than non-family, t(29) = 2.70, p < .05, dz = .35, indicating a family bias, demonstrating a bias towards categorizing family-related information than non-family-related information (Figure 4).

Accuracy A significant main effect of name stimuli was found, F(5, 145) = 19.77, p < .001, ηp² = .41 (Table 1). Paired samples t-tests between other name stimuli with self-name stimulus revealed higher accuracy for self-name than for mother name, t(29) = 3.74, p = .001, dz = .72, and friend name, t(29) = 5.96, p < .001, dz = 1.20 (Figure 3). However, accuracy for self-name was not significantly different from baby name, t(29) = 1.67, p = .11, dz = .46, experimenter name, t(29) = .65, p = .520, dz = .17, and stranger name, t(29) = -.83, p = .415, dz = .21.

No significant difference was found between family (calculated using baby and mother) and non-family (calculated using friend, experimenter and stranger), t(29) = 1.24, p = .23, dz = .30 (Figure 4).

Experiment 1c: Familiar vs. Non-Familiar Categorization

Reaction Times Results showed a significant main effect of name stimuli, F(5, 145) = 13.46, p < .001, ηp² = .35 (Table 1). Paired-samples t-tests on the name stimulus conditions showed that responses to self-name were significantly faster than baby, t(25) = -3.97, p = .001, dz = .62, mother, t(25) = -4.81, p < .001, dz = .63, friend, t(25) = -6.14, p < .001, dz = 1.29, experimenter, t(25) = -6.20, p < .001, dz = .92, and stranger names, t(25) = -6.91, p < .001, dz = .90 (Figure 3).

No significant differences were found between responses to familiar names (calculated using baby, mother, friend) and non-familiar name stimuli (calculated using experimenter, stranger), t(25) = -.78, p = .443, dz = .10 (Figure 4).

Accuracy Analysis on accuracy showed a significant main effect of name stimuli, F(5, 125) = 3.74, p < .01, ηp² = .13 (Table 1). Results for paired-samples t-tests revealed higher accuracy for self name than for friend, t(25) = 2.93, p = .007, dz = .70, experimenter, t(25) = 3.40, p = .002, dz = .78, and stranger names, t(25) = 3.29, p = .003, dz = .78. No significant differences were found between self and baby name, t(25) = .94, p = .356, dz = .28, nor between self and mother name, t(25) = 2.16, p = .04, dz = .55 (Figure 3).

No significant differences were found in accuracy between familiar (calculated using baby, mother, friend) and non-familiar name stimuli (calculated using experimenter, stranger), t(25) = .30, p = .77, dz = .06 (Figure 4).

Experiment 2: Categorization of Face Stimuli

Experiment 2a: Self vs. Others Categorization

Reaction Times A significant main effect was found for face stimulus, F(3, 87) = 14.10, p < .001, ηp² = .33 (Table 2). Paired-samples t-tests performed on the face stimuli showed that self-face resulted in
significantly faster responses than baby face, \( t(29) = -6.00, p < .001, dz = .81 \), but was not significantly different from stranger baby face, \( t(29) = -1.20, p = .239, dz = .17 \), and stranger woman face, \( t(29) = -2.16, p = .040, dz = .36 \) (Figure 5).

| Face Stimulus    | Experiment 2a: Self/Other | Experiment 2b: Family/Non-Family |
|------------------|----------------------------|----------------------------------|
|                  | RTs           | ACC    | RTs          | ACC    |
| Self             | 495 (63)      | .95 (.04) | 521 (83)     | .95 (.07) |
| Baby             | 549 (70)      | .88 (.13) | 547 (81)     | .95 (.07) |
| Stranger Baby    | 506 (64)      | .98 (.04) | 571 (81)     | .94 (.10) |
| Stranger         | 516 (52)      | .98 (.05) | 538 (69)     | .97 (.05) |

Table 2. Mean RTs (ms) and ACC (with SDs in brackets) as a function of face stimuli for Experiments 2a, 2b.

Group comparisons found that self-face stimulus elicited significantly faster responses than faces of others (calculated using baby, stranger baby, stranger woman) stimuli, \( t(29) = -3.57, p = .001, dz = .48 \) (Figure 6).

**Accuracy** Repeated measures ANOVA showed a significant main effect of face stimuli, \( F(3, 87) = 10.85, p < .001, \eta_p^2 = .27 \) (Table 2). Comparisons between self-face and other face stimuli revealed significantly higher accuracy for self-face than baby face, \( t(29) = 2.79, p = .009, dz = .60 \), but significantly lower accuracy than stranger baby face, \( t(29) = -2.95, p = .006, dz = .64 \), and stranger woman face, \( t(29) = -2.71, p = .011, dz = .61 \) (Figure 5).

No significant differences were found between self-face and faces of others (calculated using baby, stranger baby, stranger woman), \( t(29) = .57, p = .57, dz = .14 \).

Experiment 2b: Family vs. Non-Family Categorization

**Reaction Times** A repeated measures ANOVA revealed a significant main effect of face stimuli, \( F(3, 87) = 7.30, p < .001, \eta_p^2 = .20 \) (Table 2). Paired-samples t-tests found that self-face stimulus elicited significantly faster responses than stranger baby face, \( t(29) = -4.77, p < .001, dz = .61 \). However, no significant differences were found between self-face and baby face, \( t(29) = -1.98, p = .058, dz = .32 \), nor between self-face and stranger woman face, \( t(29) = -1.81, p = .082, dz = .22 \) (Figure 5).

Group comparisons showed that responses to the face of family member (calculated using baby) was not significantly faster than that of non-family (calculated using stranger baby, stranger woman), \( t(29) = -0.91, p = .37, dz = .11 \) (Figure 6).
**Accuracy** Analysis performed on the accuracy showed no significant main effect of face stimuli, F(3, 87) = 1.02, p = .39, $\eta_p^2 = .03$.

**Discussion**

The goal of this study was to explore whether becoming a mother could impact the self-concept during categorization and influence categorization for family-related information compared to other-related information. First, significantly better performance was found for self-name than names of others in family vs. non-family and familiar vs. non-familiar categorization tasks (Experiment 1b and 1c), demonstrating the presence and the stability of self-bias in the categorization process. Although many areas of human cognition have shown the presence of self-bias such as auditory and tactile perception\(^36\), it is always interesting to find new aspects of cognition that are influenced by self-bias. Moreover, the consistency of the self-bias effect indicated that the self-concept is very stable across various categorizations processes, even after the reconstruction of the self-concept due to motherhood. This notion aligns with previous research that suggest the self-concept is both stable and malleable at the same time\(^37\)-\(^39\).

Second, results from self vs. other categorization tasks (Experiment 1a and 2a) revealed much slower RTs while identifying baby name/face and mother name as not belonging to the self. In contrast, identifying friend, experimenter and stranger as not self was much easier. This indicated that the participants needed more time to separate the name/face of significant others (i.e. baby and mother) from the self. Experiment 2a also showed significantly lower accuracy for own baby face than for faces of self, stranger baby and stranger woman, suggesting that one's baby's face was particularly hard to differentiate as not belonging to the self – though it may be argued that this could be due to biological similarities between self-face and own baby's face, future studies may want to include mother-face as a comparison. These findings support the idea that one's relationship with family and friends is a major component for the construction of one's self-concept\(^40\),\(^41\). The slower RTs for baby and mother are also the main driving factors for the significant differences between self vs. other group comparisons, suggesting that kinship can have significant impact on the categorization process.

Third, names of family members (baby, mother) are processed with greater priority than names of non-family members (friend, experimenter, stranger) (Experiment 1b). In contrast, performance for familiar members (baby, mother, friend) was not significantly different from non-familiar members (experimenter, stranger) (Experiment 1c). This demonstrated a bias for categorizing family-related information but not for close non-kin such as a best friend. Based on previous research from social psychology – which proposes that the self-concept is constructed through both personal and social identities and that individuals categorizes oneself as belonging to a group if one feels a strong sense of belongingness (ingroup) or not belonging to a group if one feels a weak sense of belongingness (outgroup)\(^42\),\(^43\) – members of an ingroup are treated and evaluated in a biased way, much like the self-bias effect, to support and increase
self-regard and to feel good about the self\textsuperscript{44,45}. Thus, becoming a mother appeared to have enhanced the boundary for family and non-family members, giving prioritized processing to one's family (baby and mother) over a best friend. Although, this bias towards family members was not significantly better with face stimuli (Experiment 2a), a trend for the better performance of family member (baby) can be observed in the RTs and accuracy for own baby face than for stranger baby face. Future research may investigate this further for more conclusive results.

An interesting result was that it was difficult (i.e. longer RTs and lower ACC) for participants to categorize friends in the family/non-family (Experiment 1b) categorization task. One possibility for this is that participants might feel conflicted about how to categorize friendly non-kin into family versus non-family groups. Research found that people, especially women, treated friends more like kin\textsuperscript{46}. Another possibility is that the task, which consisted of six different name stimuli, was taxing for the participants. As a result, mothers who recently gave birth may choose to allocate more cognitive resources on family members (to ensure survival) and strangers (who pose as potential threats and competition)\textsuperscript{47}, as opposed to non-threatening close individuals such as best friends. Thus, it would be interesting to see how these results compare to those of the general population, especially those without children.

Another interesting result was that participants were significantly slower at categorizing stranger baby face as family or non-family (Experiment 2a). This is possibly due to humans having a natural attraction to infantile facial features\textsuperscript{48-50}, which was developed through evolution to motivate caregiving behavior and enhance offspring survival and development\textsuperscript{51,52}. It is also possible that postpartum biological changes made the participants more sensitive to babies than usual\textsuperscript{53}. As a result, identifying the stranger baby as non-family required more time. Although the current results do not support a general baby bias in women, the occurrence of family biases may be tested in the future with more control groups (e.g., women during pregnancy or women with no children).

Previous research involving postpartum mothers has typically taken on a more biological or developmental approach, looking at the biological changes in the mothers or studying the mother-child's interaction and development\textsuperscript{54,55}. Relatively few research has focused on the cognitive changes of the self-concept in healthy postpartum mothers. This study takes on a new approach by examining the changes from mothers' perspective to provide a more comprehensive look at the dynamic self-concept after major life experiences such as childbirth.

In conclusion, these findings support the idea that family member biases have adaptive values by prompting behaviors that facilitates offspring protection\textsuperscript{56,57} and benefit the survival of ingroup members\textsuperscript{58}, in addition to the robustness of self-biases. This marks another step toward understanding the importance of the boundary between family and non-family in postpartum mothers, indicating the stability and dynamics of the self-concept in major life experiences.

**Methods**
Experiment 1: Categorization of Name Stimuli

Experiment 1 consisted of 3 experiments – Experiment 1a, Experiment 1b and Experiment 1c. All 3 experiments examined categorization using names as stimuli. Experiment 1a focused on categorization for family or non-family members. Whilst, Experiment 1b tested categorization for self or others. Experiment 1c examined categorization for familiar or non-familiar members. Data was collected from the same group of participants.

Participants
Experiment 1a and 1b consisted of thirty healthy volunteers (mean age in years ± standard deviation = 35.82 ± 4.48) were recruited for this study. All volunteers recently gave birth (mean age of baby in months ± standard deviation = 19.76 ± 8.08) and had normal or corrected-to-normal vision. Experiment 1c was conducted slightly later than Experiment 1a and 1b. Thus, data were collected from twenty-six of the thirty-one healthy volunteers (mean age in years ± standard deviation = 35.90 ± 4.48) who recently gave birth (mean age of baby in months ± standard deviation = 19.59 ± 8.34). Informed consent was obtained from all participants prior to the experiment. The procedure used in this experiment was ethically approved by the University of Oxford Central University Research Ethics Committee. All studies were performed in accordance with the relevant guidelines and regulations.

Stimuli and materials
Experiment 1 consisted of a computer task that asked participants to make judgements on whether the stimulus was a family or non-family member. A white fixation cross was presented at the center of the screen at 0.8 x 0.8 degrees of visual angle. For task stimuli, names were obtained from the participant in a questionnaire at the start of the experiment. This includes the name of the baby, the participant (i.e. mother of the baby), the participant’s mother (i.e. grandmother of the baby), the participant’s best friend (of the same sex), the experimenter, and a stranger name picked from a list of female names. The names were entered manually at the start of the computer task in E-prime. During the computer task, one of six names – baby name, self name, mother name, friend name, experimenter name, or stranger name – was presented at the center of the screen at 1.43/3.34 x 0.5 degrees of visual angle against a grey background on a 13-inch monitor (1600 x 900 at 60 Hz). The program ran on a PC laptop using E-prime software (version 2.0). Participants responded by pressing one of two buttons on the keyboard and the order of the two buttons were counterbalanced between participants.

Procedure
Participants first completed a questionnaire that provided information about others (baby, mother, best friend and stranger). Then, the participants were asked to perform the categorization task on a laptop. Each task consisted of a learning phase and a testing phase. In the learning phase, participants learned how to perform the task correctly. The goal was to determine which category (self/other, family/non-family, familiar/non-familiar) the name stimulus belonged to. Participants were instructed to place the right index and middle finger on the corresponding buttons on the keyboard, and to respond as quickly and accurately as possible. The order of the buttons was counterbalanced across participants. A practice trial was administered in the learning phase to demonstrate and to ensure that the participant understood the task. In the testing phase, a fixation cross was presented at the center of the screen for 2000ms at the beginning of each trial, followed by a name stimulus presented at the center of the screen.
for 100ms. Next, the screen remained blank for 1100ms to collect participant response. After each response, feedback was provided for 500ms in the form of green “Correct”, red “Incorrect”, or yellow “Too Slow!” when no response was given within the time window, (Fig. 2). Participants completed one block of categorization task, which consisted of 16 trials per condition. Feedback on overall accuracy was provided at the end of the task.

Experimental Design and Data Analyses Data were analyzed and reported in two sections – RTs and accuracy – for each categorization task. RTs faster than 200ms were excluded and mean correct RTs were calculated for each condition. For the analyses, a repeated measures ANOVA was first performed on the name stimuli, followed by paired-samples t-tests to test the differences between each name stimulus as well as the group differences between family (baby, mother) and non-family (friend, experimenter, stranger). Bonferroni correction was applied for multiple comparisons in paired-samples t-tests.

Experiment 2: Categorization of Face Stimuli

Experiment 2 consisted of 2 experiments – Experiment 2a and 2b. Experiment 2a tested categorization for family (baby) or non-family (stranger baby, stranger woman) and Experiment 2b examined categorization for self or others (baby, stranger baby, stranger woman). The data were collected from the same group of participants as Experiment 1.

Participants Please see Participant in Experiment 1.

Stimuli and materials Instead of names, Experiment 2a and 2b used photos of faces as stimuli to examine categorization for family/non-family and self/other. Categorization for familiar/non-familiar was not conducted due to difficulties in obtaining photos ahead of time. Participants were recruited on the spot from the Baby Lab at the University of Oxford by approaching and asking if the mother was interested in taking part in the study. Thus, no preparations could be made ahead of time concerning photos. Additionally, photos provided ahead of time could introduce confounds that would have been difficult to control, such as lighting, participant expression, and other aspects of the photo due to having been taken under different environments and circumstances. Thus, to ensure that photos for making the face stimuli was controlled as much as possible, Experiment 2a and 2b only consisted of 4 face stimuli – baby face, self face, stranger baby face, and stranger woman face. The stranger faces – stranger baby and stranger woman – were collected during a pilot study and consent to use these photos for research purposes was obtained. Photos of babies of different ages (in months) were taken so that the age would match between participant’s baby and stranger baby. Stranger woman face was of a staff member who recently gave birth.

Both the face photos of the participant’s baby and the participant were taken and edited before the start of the experiment. Photos of each participant was taken against a white wall under the same artificial lighting and the participants were instructed to pose with a neutral expression. Photos of the participant’s baby were also taken under the same conditions when possible. However, it was not always practical to photograph the baby with a neutral expression under the same lighting and background (e.g. baby refuse
to stop smiling, baby refuse to look at the camera). In these cases, the most neutral face was selected to make the stimulus, and photos were edited to about the same level of luminance as the others. The photos were also edited into an oval shape to show only the face with as little hair showing as possible, and to exclude any background or other information.

During the tasks, one of four faces – self face, baby face, stranger baby face, stranger woman face – was displayed at the center of the screen with a width of 3 degrees of visual angle. The height of the photos was scaled accordingly based on the width of the photo to accommodate the different shapes of participant faces.

**Procedure** Experiment procedure for this study was the same as Experiment 1, except that there were only 4 face stimulus conditions – self face, baby face, experimenter face, and stranger woman face (Fig. 2). The goal of Experiment 2a was to investigate categorization for family versus non-family members and Experiment 2b examined the difference between self-face stimulus and other face stimulus. Please refer to the procedure section in Experiment 1a for more details.

**Experimental Design and Data Analyses** Consistent with Experiment 1, data were analyzed and reported in RTs and accuracy. RTs faster than 200ms were excluded and mean correct RTs were calculated for each condition. A repeated measure ANOVA was first performed using face stimulus as the within-subjects variable. Then, group differences between self and other was compared using paired-samples t-tests. Bonferroni correction was applied for multiple comparisons in paired samples t-tests.

**Declarations**

Data Availability statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions statement

M.J. and J.S. conceived the experiments, M.J. conducted the experiments, M.J. collected the data and analysed the results. M.J. wrote the main manuscript text and prepared all the figures and tables. All authors reviewed and approved the final version submitted for publication.

Competing interests The authors declare no competing interests.
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**Figures**

**Figure 1**

*Categorization of the self and others into various groups.*

**Figure 2**

*Experiment design. A demonstration of the (A) experiment procedure, (B) experiment tasks, and (C) trial procedure.*

**Figure 3**

*Comparisons between the self and each of the other stimulus conditions in Experiment 1. Mean RTs (left) and ACC (right) as a function of name stimulus and categorization task (Experiment 1a, 1b and 1c). Error bars represent one standard error. Significant differences are marked with ‘**’ (p < .01).*

**Figure 4**

*Comparisons between the group categories in Experiment 1. Mean RTs (left) and ACC (right) as a function of name categorization task (self vs. other, family vs. non-family, familiar vs. non-familiar) in Experiment 1a, 1b, 1c. Error bars represent one standard error. Significant differences are marked with ‘*’ (p < .05) and ‘**’ (p < .01).*

**Figure 5**

*Comparisons between the self and each of the other stimulus conditions in Experiment 2. Mean RTs (left) and ACC (right) as a function of face stimulus and categorization task (Experiment 2a and 2b). Error bars represent one standard error. Significant differences are marked with ‘*’ (p < .05) and ‘**’ (p < .01).*
Figure 6

Comparisons between the group categories in Experiment 2. Mean RTs (left) and ACC (right) as a function of face categorization task (self vs. other, family vs. non-family) in Experiment 2a, 2b. Error bars represent one standard error. Significant differences are marked with ‘**’ (p < .01).