Real-life experience with personally familiar faces enhances discrimination based on global information

Meike Ramon[1,2] & Goedele Van Belle[1]

[1]*University of Louvain, Louvain-la-Neuve, Belgium*

[2]*University of Glasgow, Glasgow, United Kingdom*

Université catholique de Louvain

Institute of Research in Psychology

10, Place du Cardinal Mercier

B1348 Louvain-La-Neuve

Belgium

email: meike.ramon@uclouvain.be

Acknowledgements

MR is supported by the Belgian National Foundation for Scientific Research (FNRS). The authors express their gratitude to Bruno Rossion, under the supervision of which the experiments were carried out. Further thanks are directed to all participants for their cooperation.

1 **Abstract**

2 Despite the agreement that experience with faces leads to more efficient processing, the

3 underlying mechanisms remain largely unknown. Building on empirical evidence from

4 unfamiliar face processing in healthy populations and neuropsychological patients, the present

5 experiment tested the hypothesis that personal familiarity is associated with superior

6 discrimination when identity information is derived based on global, as opposed to local facial

7 information. Diagnosticity and availability of local and global information was manipulated

8 through varied physical similarity and spatial resolution of morph faces created from

9 personally familiar, or unfamiliar faces. We found that discrimination of subtle changes

10 between highly similar morph faces was unaffected by familiarity. Contrariwise, relatively

11 more pronounced physical (i.e., identity) differences were more efficiently discriminated for

12 personally familiar faces, indicating more efficient holistic processing of facial information

13 through real-life experience.

14 Keywords: Face processing, personal familiarity, real-life exposure, global information

15 integration, holistic processing

1   **Introduction**

2   Humans are highly efficient at processing faces of conspecifics. Within a few hundred

3   milliseconds, we can categorize faces according to their gender, expression, race and

4   familiarity, as well as identify them. The social importance of face processing, and its

5   complexity as a perceptual and cognitive process has motivated numerous investigations of

6   the underlying mechanisms. Several lines of research indicate that processing of identity

7   information is linked to observers ability to integrate global facial information, also referred to

8   as holistic processing, a hallmark of adult's face processing expertise (McKone, Kanwisher, &

9   Duchaine, 2007; Mondloch, Pathman, Maurer, Le Grand & de Schonen, 2007; Richler &

10   Gauthier, 2013). Neuropsychological studies have demonstrated that face processing deficits

11   observed in prosopagnosia can be accounted for by patients' impairment of holistic processing

12   (e.g., Ramon, Busigny & Rossion, 2010; for a review see Rossion, 2014). Furthermore, recent

13   evidence suggests a direct relation between the extent of holistic processing and healthy

14   observers' face processing efficiency (Wang et al., 2012).

15   While the most impressive demonstration of humans' face processing ability is

16   observed for *familiar* faces, the bulk of empirical evidence regarding its determinants stems

17   from experiments involving *unfamiliar* face stimuli. Several studies indicate that personally

18   familiar faces are processed more efficiently than their unfamiliar counterparts (e.g., Bruce,

19   Henderson, Greenwood, Hancock, Burton & Miller, 1999; Burton, Wilson, Cowan & Bruce,

20   1999; Ramon, Caharel & Rossion, 2011). Familiar identities can be behaviorally categorized

21   as such significantly faster than unfamiliar faces, within as little as 310 ms (Ramon, Caharel

22   & Rossion, 2010; see also Busigny, Bled, Besson & Barbeau, 2012), with differential

23   electrophysiological responses occuring 100 ms prior (Caharel, Ramon & Rossion, 2014).

24   Moreover, the presence of an underlying facial representation stored in memory makes

25   perceptual processing more robust to variations in the input characteristics. For instance, we

26   can easily recognize a famous or personally familiar face based on their eyes alone (Sadr,

27   Jarudi & Sinha, 2003; Ramon, Busigny, Gosselin & Rossion, in preparation), or from a highly

1 degraded image (Watier & Collin, 2009; Loftus & Harley, 2005; Ramon et al., in preparation),

2 and even after considerable time periods (Bahrick, Bahrick & Wittingler, 1975). Contrariwise,

3 identity processing in unfamiliar faces is highly dependent on the visual characteristics of the

4 stimulus input, i.e., availability of color, texture, and surface reflectance (Russell, Sinha,

5 Biederman & Nederhouser, 2006; Jiang, Blanz & Rossion, 2011), and is hence more prone to

6 error given superficial image variations (e.g., viewpoint or image quality; Bruce 1986;

7 Roberts and Bruce 1989; Bruce, Henderson, Newman & Burton, 2001).

8   Together, these observations support the general consensus that unfamiliar and

9 personally familiar faces are processed differently (cf., Tong & Nakayama, 1999; Megreya &

10 Burton, 2006; Carbon, 2008; Gobbini et al., 2013). However, there is little understanding of

11 the underlying mechanisms promoting such differential processing. While early studies using

12 famous faces have suggested that familiarity affects processing of internal facial information

13 in general (Ellis, Shepherd & Davies, 1979; Young, Hay, McWeeny, Flude & Ellis, 1985;

14 Brooks & Kemp, 2007), other investigations have provided inconsistent results regarding

15 whether or not its effects are restricted to processing of the eyes only (O'Donnell & Bruce,

16 2001), or extends to the less salient mouth region (Barton, Radcliffe, Cherkasova, Edelman &

17 Intriligator, 2006; Van Belle, Ramon, Lefèvre & Rossion, 2010). However, more recent

18 findings may reconcile these seemingly conflicting findings. Ramon (2015a,b) reported that

19 personal familiarity affects discrimination of vertical displacements of the eyes and the mouth,

20 as well as changes of the overall configuration between these two sources of information.

21 These findings suggest that personal familiarity may not affect processing of specific *types* of

22 facial information, but rather modulate the *processing style* engaged in.

23   The present study sought to extend these previous findings by varying the degree to

24 which local or global information was diagnostic for identity discrimination. The underlying

25 idea is that personal familiarity facilitates perceptual processing, and thus discrimination of

26 faces through the presence of a facial representation in memory. Given the relationship

27 between holistic processing and processing of identity (Sergent, 1984; Tanaka & Farah, 1993,

1   2003), our hypothesis was that such enhanced perceptual processing for familiar compared to

2   unfamiliar faces would be observed along with decreased reliance on local, piecemeal

3   information.

4   In a delayed matching paradigm, observers performed forced-choice decisions of facial

5   identity. The face stimuli used to this end were derived from morph continua similar to those

6   used in investigations of categorical perception of identity, or expression (Beale and Keil,

7   1995 ; Gilaie-Dotan & Malach, 2005; Fox, Moon, Iaria & Barton, 2009; Ramon, Dricot &

8   Rossion, 2010). The parametric variations in identity-related physical information offered a

9   means to manipulate the perceptual similarity and hence ambiguity of information supporting

10   discriminative decisions.[1] While dissimilar stimuli could be more easily discriminated based

11   on global information, discrimination of more similar ones would be comparably less efficient

12   and require more local distinctive feature sampling. Hence, our experimental conditions

13   differed in the extent to which discrimination would be based on global, or holistic processing

14   (defined here as the fast and automatic process leading to an internal representation of the face

15   as a whole; Galton, 1883; Rossion, 2013).

16   Importantly, to investigate whether personal familiarity selectively affects global

17   processing, or leads to a general processing advantage, two groups of observers completed the

18   same task. Control subjects were unfamiliar with *all* of the identities depicted. The

19   experimental group comprised subjects who were highly personally familiar with *half* of the

20   identities, which represented their classmates.

21   Thus, contrary to previous studies, we varied two aspects that are considered to

22   modulate observers face processing efficiency. On the one hand, the physical similarity of

23   face stimuli (which co-varies with discrimination efficiency based on global information), as

24   well as observers' familiarity with face stimuli. In line with the high discrimination

---

[1] Previous studies have demonstrated that increased physical similarity is associated with decreased discriminability and therefore more piecemeal processing of local cues (e.g. pixel-based intensity, or color differences; Barton et al., 2006; Orban de Xivry, Ramon, Lefèvre & Rossion, 2008; Busigny, Graf, Mayer & Rossion, 2010; Van Belle, Lefèvre & Rossion, 2012), i.e. decreased reliance on initial holistic or global processing. Note that other authors have applied the same morphing techniques to e.g. identities differing merely in regard to a single feature (Goffaux, 2012) or a metric relation between features (Gilad-Gutnik, Yovel & Sinha, 2012).

1   performance reported for familiar vs. unfamiliar face discrimination, a beneficial effect of

2   familiarity was anticipated for conditions of low similarity considered to involve reliance on

3   global information. Contrariwise, no such familiarity-related advantage was expected for

4   discrimination of highly similar faces, which would rely on observers' ability to identify

5   locally circumscribed details.

6   Naturally, local details are also available in conditions of low similarity, and thus could

7   be used for face discrimination. Therefore, we incorporated a third condition involving low

8   similarity. Here, the local, high resolution information was made unavailable through stimulus

9   blurring (Sergent, 1986; Collishaw & Hole, 2000; Schwaninger, Wallraven, Cunningham &

10   Chiller-Glaus, 2006; Gilad-Gutnick et al., 2012). Thus, we removed high spatial frequency

11   information typically used for piecemeal analytic processing (Goffaux, 2009; Goffaux &

12   Rossion, 2006).

13   In sum, we manipulated stimulus similarity, availability of high resolution local details,

14   as well as personal familiarity to directly test—for the first time to our knowledge—the

15   hypothesis that familiarity leads to an advantage in global/holistic, but not local processing.

16   Two possible outcomes were anticipated. First, if familiarity were associated with an

17   advantage at processing local discriminative information, we should observe a familiarity

18   advantage across both conditions involving high resolution images enabling the use of said

19   information. Alternatively, if familiarity is advantageous for automatic global processing, we

20   should observe an experience-related benefit for conditions involving low stimulus

21   similarity—regardless of whether high spatial information used for local information

22   processing is available.

23   **Methods**

24   ***Procedure and apparatus***

25   Participants performed a two to one alternative forced-choice delayed matching task.

26   Each trial started with a centrally presented fixation cross. Upon fixation of the central

1   fixation cross, two probe faces (distance between the inner borders: 5° of visual angle) were

2   presented side by side for 2.5s. This pair of probe faces was followed by a single test face,

3   which was identical to one of the two probes (sides counterbalanced) and remained on screen

4   until participants indicated to which of the probes the test face corresponded by pressing the

5   corresponding left or right arrow button on the keyboard. The next trial was initiated

6   immediately after each response.

7   The experiment consisted of six blocks of 40 trials in total. There were 3 blocks for

8   familiar, and 3 blocks for unfamiliar face stimuli, respectively. Each block, consisted of trials

9   of one of the three experimental conditions (Full 20%, full 50%, blur 50%; see below). The

10   order of the blocks in terms of familiarity and similarity condition was counterbalanced across

11   participants (note that control subjects were unfamiliar with all faces used as stimuli; see

12   below). Within each block there was an equal amount of left and right correct response sides

13   and both faces from each of the 10 stimulus pairs appeared twice as the test stimulus. This

14   procedure ensured equal likelihood of perceiving either identity (see Ramon et al., 2010).

15   To become familiar with the task, participants completed 5 practice trials prior to the

16   main experiment. These practice trials contained faces that were not used in the main

17   experiment and were excluded from analysis. Stimuli were displayed using Presentation or

18   Eprime software, on a 22" Sony Trinitron monitor (58cm viewing distance, 1400 x 1050 pixel

19   resolution, 85 Hz refresh rate). Probe and test faces' height comprised 10.3 and 11.5° of visual

20   angle, respectively. This roughly corresponds to the size of a real face viewed at normal

21   conversational distance of 90 cm (Hall, 1966). Both stimulus display and response registration

22   was controlled by an Intel Centrino vPro.

23   ***Stimuli***

24   Two different sets of stimuli were used in the main experiment. The first was taken

25   from a previous study (Ramon et al., 2010) and involved 10 morph continua, the extremes of

26   which were unfamiliar to all participants. An additional set of 10 morph continua were created

27   between pairs of faces with which half of the participants were personally familiar: their

1   classmates. To this end full-front photographs of 26 students of the same class were taken

2   under identical conditions (distance, lighting). The photographs of five male and one female

3   student were excluded from the final set of familiar faces used, due to the presence of facial

4   hair or make-up at the time the photographs were taken. Using Adobe Photoshop, the

5   remaining 20 familiar face stimuli were cropped of external features and hair (see Figure 1a)

6   and morph continua were created with Photo Morpher v3.10 (Morpheus, Santa Barbara, CA,

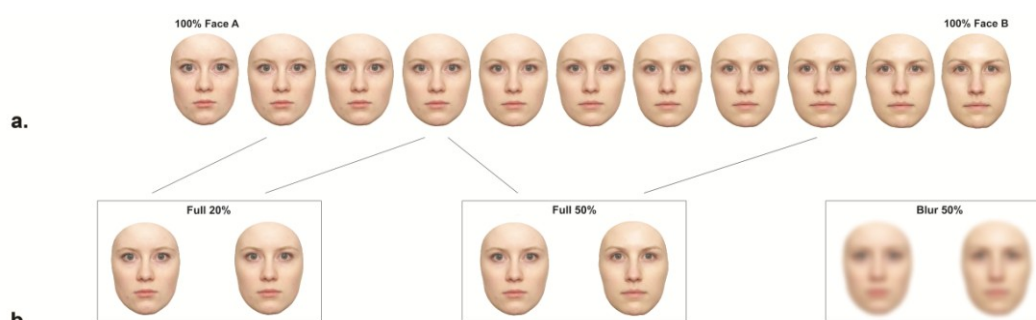
7   USA) following the same procedure as used by Ramon et al. (2010). Specifically, face pairs

8   were selected based on eye color, shape and overall luminosity of the face. For each face, 350

9   points were placed on the critical features (encompassing the pupils, iris, eye bulbs, eye lids,

10   eye brows, mouth, nose and overall facial contour) to allow smooth transitions between the

11   stimuli created per morph continuum (two original faces representing the extremes, with 10%

12   increments; see Figure 1a).

14 **Figure 1. Stimuli discriminated in the delayed matching task. a.** An example of an unfamiliar face morph
15 continuum. Unfamiliar stimuli were those used by Ramon et al. (2010), which were unfamiliar to all subjects
16 tested. Familiar morph continua were created from pairs of classmates of experimental subjects tested, and were
17 unfamiliar to control subjects. **b.** Examples of stimulus pairs to be discriminated in the 2AFC delayed matching
18 task (pairs were taken from either side of a continuum; see Ramon et al., 2010).

19   As described above, our hypothesis states that personal familiarity would facilitate

20   discrimination of faces by an amount *depending on their physical similarity*. We therefore

21   created 3 conditions resulting in three degrees of reliance on local distinctive features, and

22   therefore three different degrees at which performance is determined by global processing.

23   The first condition involved probe face pairs of stimuli differing by 20% (physically similar

24   pairs, *Full 20%*) that were located on the same side of the categorical boundary of the morph

25   continua (i.e., the point where both identities would be perceived with equal likelihood; see

26   e.g. Beale & Keil, 1995; Gilaie-Dotan & Malach, 2007; Ramon et al., 2010; Rotshtein,

1   Henson, Treves & Driver & Dolan, 2005). The second condition involved pairs of stimuli

2   which differed by 50% (physically dissimilar pairs, *Full 50%*) and were located on opposite

3   sides of the categorical boundary of the morph continua. Note that the distance of these more

4   dissimilar items relative to both extremes (i.e., original faces) and the categorical boundary

5   was identical to the physical difference between *Full 20%* pairs (see Figure 1).[2] In the full

6   20% condition the faces are more similar than in the Full 50% condition, making the

7   comparison more ambiguous, and comparably more dependent on local information. A third

8   condition involved the same dissimilar pairs (*Full 50%*), to which a Gaussian blur (30 pixel

9   radius; see e.g., Gilad-Gutnik et al., 2012) was applied in order to make high resolution

10 information (e.g., freckles, wrinkles, etc.) less available (physically dissimilar pairs of blurred

11 faces, *Blur 50%*). As described above, this was done to disable to the use of local features in

12 conditions of low similarity.

13 ***Participants***

14   Twelve participants (mean age: 23±1; 3 male), who were personally familiar with half

15 of the individuals depicted in the stimuli (from here on referred to as 'experimental group',

16 were financially compensated for their participation. They were all senior year psychology

17 master students who had been following classes in the same group of ~30 students for about 2

18 years at the time of testing; some knew each other for a maximum of 5 years (data collection

19 occurred while students were still in the cohort). The control group comprised 12 participants

20 (mean age: 25±4; 4 male), who were unfamiliar with the entire set of individuals used to

21 create the face images used, and were also financially compensated for participation. The

22 experiments were undertaken with the understanding and written consent of each subject, and

23 conform to The Code of Ethics of the World Medical Association (Declaration of Helsinki).

---

[2] For trials on which probe stimuli differed by 20% (*Full 20%*, see Figure 1a), probes were selected to depict a given identity by 90% and 70% (test stimuli always depicted a given identity by 90%). For trials on which probe stimuli differed by 50% (*Full 50%*, *Blurred 50%*), the probes represented a given identity by 70% and 20%; test stimuli always depicted a given identity by 20%.

1   *Analyses*

2   The analyses were conducted separately on accuracy scores and correct RTs as

3   individual subjects may differ in terms of the measure they exhibit performance differences

4   (Pachella, 1974; Meyer, Irwin, Osman & Kounios, 1988). For each subject and condition

5   separately, familiarity indexes ((familiar – unfamiliar) / (familiar + unfamiliar)) were

6   computed for accuracy and correct RTs to capture potential effects of stimulus familiarity

7   (which in the case of the control group would capture any perceptual differences between the

8   sets of stimuli, which were both unfamiliar to them). These familiarity indexes will further be

9   referred to as '*the familiarity advantage*'. Using SPSS, we conducted a mixed model repeated

10   measures ANOVA on the familiarity advantage with one between-subjects factor (group:

11   *experimental vs. control*), and one within-subject factor (condition: *Full 50%, Full 20%, Blur*

12   *50%*). Post-hoc contrasts between individual factor level combinations were Bonferroni

13   corrected. Raw accuracy and RT values per group and condition, as well as 95% bootstrapped

14   confidence intervals can be found in the supplemental material (Table S**1**). None of the

15   conditions was associated with performance at chance or ceiling level.

16   **Results**

17   The analyses conducted on the familiarity indexes (reflecting potentially beneficial

18   effects of stimulus familiarity assumed for the experimental group, as controls were

19   unfamiliar with both stimulus sets used; see Methods) revealed a main effect of condition for

20   accuracy scores ($F_{(2,44)}$=16.11, *p<.01*, η_P^2 =.42), as well as for normalized RTs

21   ($F_{(2,44)}$=3.65, *p<.05*, η_P^2=.14). There was also a main effect of group, with generally larger

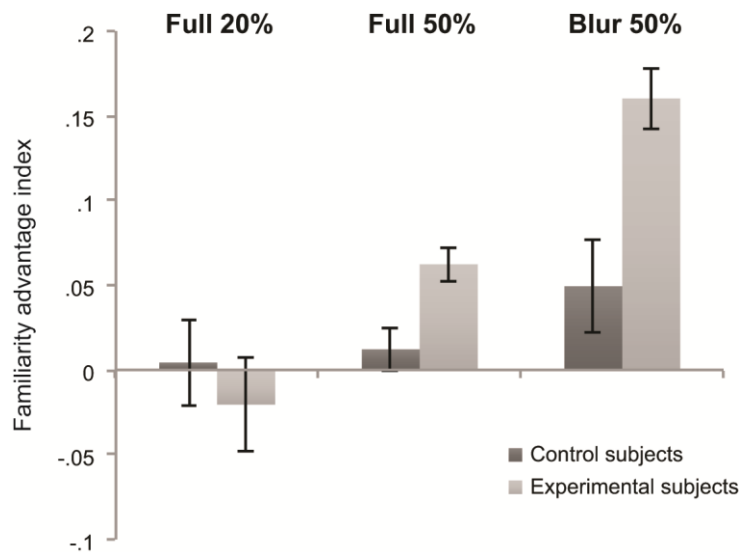
22   familiarity advantages for the experimental, than the control group for accuracy

23   ($F_{(1,22)}$=5.39, *p<.05*, η_P^2 =.20), but not for RTs ($F_{(1,22)}$=.25, *p=.62*, η_P^2 =.01). Most

24   importantly, for accuracy scores we observed a significant interaction between group and

25   condition ($F_{(1,22)}$=3.76, *p<.01*, η_P^2 =.15), which was again not significant for RTs

1   (F(2,44)=1.63, *p=.21*, η^2_P=.07). Group means of the familiarity advantage for accuracy across

2   conditions are displayed in Figure 2.

4   **Figure 2. Familiarity advantage in the 2AFC delayed matching task with personally familiar and unfamiliar**
5   **morph stimuli.** Mean familiarity advantage ((familiar – unfamiliar) / (familiar + unfamiliar)) for accuracy scores
6   per condition observed for control, as well as experimental subjects. Error bars represent standard errors for both
7   measures. Note that for control subjects, all faces were unfamiliar.

8   Further investigation of the interaction effect for accuracy revealed that the familiarity

9   advantage was larger for the experimental group than for the control group in the Full 50%

10 condition (t=3.08, *p<.01*) and in the Blur 50% condition (t=3.41, *p<.01*), but not in the Full

11 20% condition (t=.66, *p=.52*). Furthermore, all differences between conditions in the

12 experimental group were significant, with a smaller familiarity advantage in the Full 20% than

13 Full 50% (t=2.75, *p<.05*) condition, and even larger in the Blur 50% (t=4.16, *p<.01*) than the

14 Full 50% condition. In the control group, the difference between familiar and unfamiliar

15 stimuli did not significantly vary across conditions (*ps>.05*).

16 **Discussion**

17   Several lines of empirical evidence suggest a relationship between face processing

18 efficiency and the ability to process faces holistically, i.e., the ability to rapidly integrate

19 information from across the entire face into a unified percept. Some studies indicate a direct

20 association between the degree of holistic processing exhibited by healthy observers, and the

21 efficiency with which upright faces are processed (e.g., Wang et al., 2012). Experimental

1   manipulations utilized to disrupt holistic processing include stimulus inversion, as well as

2   increased physical stimulus similarity. Both lead to reliable decreases in face processing

3   performance and have been associated with employment of a more local/featural processing

4   style (Barton et al., 2006; Orban de Xivry et al., 2008, Van Belle, De Graef, Verfaillie,

5   Busigny & Rossion, 2010), a phenomenon also observed in patients with prosopagnosia (i.e.,

6   the face selective recognition deficit due to brain damage), who have lost the ability to process

7   faces holistically (e.g., Bukach, Le grand, Kaiser, Bub & Tanaka, 2008; Busigny & Rossion,

8   2010; Ramon et al., 2010a; Van Belle, Busigny, Lefèvre, Joubert, Felician, Gentile, Rossion,

9   2011; Van Belle, De Graef, Verfaillie, Busigny & Rossion, 2010; Van Belle, Lefèvre,

10   Laguesse, Busigny, De Graef & Verfaillie, 2010; Rossion, 2014).

11   The present study aimed to investigate the effect of repeated, real-life experience with

12   personally familiar individuals on perceptual processing of faces. Naturally, healthy observers

13   have no difficulty in determining the identity of familiar individuals (see also e.g., Jenkins,

14   White, Van Montfort & Burton, 2011; Ramon et al., in preparation)—a task for which ceiling

15   effects can be expected. To manipulate the relative reliance on global versus local information

16   processing for face discrimination, the stimulus material used here involved morph faces of

17   varied physical similarity (e.g. Beale & Keil, 1995; Gilaie-Dotan & Malach, 2007; Ramon et

18   al., 2010b; Rotshtein et al., 2005). Following previous research, discrimination of highly

19   similar faces was assumed to be less efficient and rely more on processing of local details

20   (Barton et al., 2006; Orban de Xivry et al., 2008). Contrariwise, dissimilar faces were

21   anticipated to be distinguished more efficiently given automatic extraction of global

22   information from across the entire face.

23   Most importantly, the experimental subjects tested here were personally familiar with

24   half of the individuals used to create the morph stimuli presented. That is, not only did the

25   face stimuli differ in their respective physical similarity, but also regarding the presence of a

26   facial representation stored in memory. Replicating previous findings (e.g., Bruce et al., 1999;

27   Burton et al., 1999; Ramon et al., 2011; Ramon, 2015a,b), we found that personal familiarity

1   was associated with enhanced face discrimination performance. Using morph stimuli differing

2   in physical similarity and subjects' familiarity, we sought to determine whether this

3   enhancement is due to more efficient global, as opposed to local processing; two potential

4   outcomes were anticipated. First, selectively increased performance for familiar versus

5   unfamiliar faces for high resolution images only (i.e., irrespective of physical (dis)similarity)

6   would indicate higher efficiency at selecting discriminative local features for familiar than for

7   unfamiliar faces. Alternatively, a familiarity-dependent advantage for discrimination of

8   *dissimilar* faces only (i.e., for both high resolution and blurred images) would support the idea

9   of experience-related increased efficiency for processing facial identity based on global or

10   holistic processing.

11   The performance profiles observed for the discrimination of morph stimuli created

12   from *personally familiar faces* was markedly different from that of unfamiliar faces. First,

13   discrimination of highly similar (*Full 20%*) face morphs, which highly relies on local/featural

14   processing (e.g., Barton et al., 2006; Orban de Xivry et al., 2008), was unaffected by

15   familiarity. This finding, which cannot be accounted for in terms of floor effects, indicates

16   that familiarity, i.e., extensive prior real-life experience does not lead to more proficient

17   performance when processing relies on local information. Note that this coincides with Barton

18   et al.'s (2006) findings that higher ambiguity and lack of familiarity lead to an increase in

19   difficulty of perceptually based decisions as well as the need to accumulate more data (in their

20   study: more fixations, longer durations; see also Althoff & Cohen, 1999). Second, mirroring

21   the high efficiency with which personally familiar faces are generally processed, performance

22   increased when discrimination of high-resolution, dissimilar faces (*Full 50%*) was required.

23   Moreover, performance at discriminating the same level of similarity was superior for familiar

24   relative to unfamiliar stimuli *despite* the unavailability of high-resolution, local information

25   (*Blur 50%*).

26   These results are interpreted as a clear indication that facial representations stored in

27   memory, as is the case for personally familiar faces, lead to enhanced global processing and

1   less reliance on high resolution local information for face discrimination. This is consistent

2   with Rossion's (2013) description of the role of visual experience for holistic processing.

3   Indeed, previous studies exploring the effects of cross-cultural and cohort-dependent exposure

4   have reported increased holistic processing and superior face discrimination for faces with

5   which subjects had extensive exposure, e.g., own-race (Michel, Rossion, Han, Chung &

6   Caldara, 2006; Michel, Corneille & Rossion, 2007), own-age faces (de Heering & Rossion,

7   2008; Kuefner, Macchi Cassia, Picozzi & Bricolo, 2008), and faces presented in their

8   canonical orientation (Van Belle et al., 2010b). The present findings thus add to a body of

9   evidence suggesting a direct relationship between experience, increased holistic processing

10 and face processing efficiency (see also e.g. Crookes, Favelle & Hayward, 2013; Degutis,

11 Mercado, Wilmer & Rosenblatt, 2013; Susilo, Crookes, McKone & Turner, 2009; Proietti,

12 Pisacane & Macchi Cassia, 2013). In fact, the present findings go even further, by showing

13 that holistic processing is modulated not only by visual experience with the face category, but

14 also by visual experience with individual faces, i.e. specific exemplars. Based on our findings

15 we suggest that the global percept of an individual face can be influenced by an underlying

16 representation obtained through real-life interactions and stored in memory. In keeping with

17 the observation that personally familiar face identification is robust across viewing distances

18 (Ramon, 2015b) and therefore efficient even provided only low spatial frequency information,

19 we observed that familiarity was associated with a decreased reliance on local details for

20 discrimination of facial identity.

21   In sum, these observations demonstrate that personal familiarity acquired through

22 repeated, real-life interactions facilitates face discrimination through enhanced holistic

23 processing. As such, they expand our current knowledge about the role of experience for

24 holistic processing by demonstrating that not only experience with categories of faces, but

25 also with individual faces can modulate their perceptual processing.

1 **References**

2 Althoff RR & Cohen NJ (1999). Eye-movement-based memory effect: a reprocessing effect in

3   face perception. J Exp Psychol Learn Mem Cogn, 25, 997-1010.

4 Bahrick HP, Bahrick PO & Wittingler RP (1975). Fifty years of memory for names and faces:

5   A cross-sectional approach. J Exp Psychol Gen, 104, 54-75.

6 Barton JJ, Radcliffe N, Cherkasova MV, Edelman J & Intriligator JM (2006). Information

7   processing during face recognition: the effects of familiarity, inversion, and morphing on

8   scanning fixations. Perception, 35, 1089-1105.

9 Beale JM & Keil FC (1995). Categorical effects in the perception of faces. Cognition, 57,

10   :217-39.

11 Brooks KR & Kemp RI (2007). Sensitivity to feature displacement in familiar and unfamiliar

12   faces: beyond the internal/external feature distinction. Perception, 36, 1646-59.

13 Bruce V (1986). Influences of familiarity on the processing of faces. Perception ,15, 387-97.

14 Bruce V, Henderson Z, Greenwood K, Hancock P, Burton M & Miller P (1999). Verification

15   of face identities from images captured on video. J Exp Psychol Appl, 5, 339–360.

16 Bruce V, Henderson Z, Newman C & Burton AM (2001). Matching identities of familiar and

17   unfamiliar faces caught on CCTV images. J Exp Psychol Appl, 7, 207-18.

18 Bukach CM, Le Grand R, Kaiser MD, Bub DN & Tanaka JW (2008). Preservation of mouth

19   region processing in two cases of prosopagnosia. J Neuropsychol, 2, 227-44.

20 Burton AM, Wilson S, Cowan M & Bruce V (1999). Face recognition in poor quality video:

21   evidence from security surveillance. Psychological Science, 10, 243-8.

22 Busigny T & Rossion B (2010). Acquired prosopagnosia abolishes the face inversion effect.

23   Cortex, 46, 965-81.

1   Busigny T, Bled C, Besson G & Barbeau EJ (2012), The speed of face recognition: A 50ms
2   gain between personally familiar faces and famous faces. Perception 41 ECVP Abstract
3   Supplement, page 20.

4   Busigny T, Graf M, Mayer E & Rossion B (2010). Acquired prosopagnosia as a face-specific
5   disorder: ruling out the general visual similarity account. Neuropsychologia, 48, 2051-67.

6   Caharel S, Ramon M & Rossion B (2014). Face familiarity decisions take 200 msec in the
7   human brain: electrophysiological evidence from a go/no-go speeded task. J Cogn
8   Neurosci, 26, 81-95.

9   Carbon CC (2008). Famous faces as icons. The illusion of being an expert in the recognition
10   of famous faces. Perception, 37, 801-806.

11 Collishaw SM & Hole GJ (2000). Featural and configurational processes in the recognition of
12   faces of different familiarity. Perception, 29, 893-909.

13 Crookes K, Favelle S & Hayward WG (2013). Holistic processing for other-race faces in
14   chinese participants occurs for upright but not inverted faces. Front Psychol, 4:29. doi:
15   10.3389/fpsyg.2013.00029.

16 de Heering A & Rossion B (2008). Prolonged visual experience in adulthood modulates
17   holistic face perception. PLoS One, 3(5):e2317.

18 Degutis J, Mercado RJ, Wilmer J & Rosenblatt A (2013). Individual differences in holistic
19   processing predict the own-race advantage in recognition memory. PLoS One,
20   8(4):e58253.

21 Ellis HD, Shepherd JW & Davies GM (1979). Identification of familiar and unfamiliar faces
22   from internal and external features: some implications for theories of face recognition.
23   Perception, 8, 431-9.

Fox CJ, Moon SY, Iaria G, Barton JJ (2009). The correlates of subjective perception of identity and expression in the face network: an fMRI adaptation study. Neuroimage, 44:569-80.

Galton, F. (1883). Inquiries into human faculty and its development. London: Macmillan

Gilad-Gutnick S, Yovel G & Sinha P (2012). Recognizing degraded faces: the contribution of configural and featural cues. Perception, 41, 1497-511.

Gilaie-Dotan S & Malach R (2007). Sub-exemplar shape tuning in human face-related areas. Cereb Cortex, 17, 325-38.

Gobbini MI, Gors JD, Halchenko YO, Rogers C, Guntupalli JS, Hughes H & Cipolli C (2013). Prioritized Detection of Personally Familiar Faces. PLoS One, 21;8(6):e66620.

Goffaux V (2012). The discriminability of local cues determines the strength of holistic face processing. Vision Research, 64:17-22.

Goffaux, V. & Rossion, B. (2006). Faces are "spatial"--holistic face perception is supported by low spatial frequencies. Journal of experimental psychology. Human perception and performance 32, 1023-1039.

Goffaux, V. (2009). Spatial interactions in upright and inverted faces: re-exploration of spatial scale influence. Vision research, 49, 774–781

Hall, ET (1966). The Hidden Dimension. New York: Doubleday.

Jenkins R, White D, Van Montfort X & Mike Burton A (2011). Variability in photos of the same face. Cognition, 121, 313-23.

Jiang F, Blanz, V & Rossion B. (2011). Holistic processing of shape cues in face identification: evidence from face inversion, composite faces and acquired prosopagnosia. Visual Cognition, 19, 1003-1034.

Kuefner D, Macchi Cassia V, Picozzi M & Bricolo E (2008). Do all kids look alike? Evidence for an other-age effect in adults. J Exp Psychol Hum Percept Perform, 34, 811-7.

Loftus GR & Harley EM (2005). Why is it easier to identify someone close than far away? Psychon Bull Rev, 12: 43-65.

McKone E, Kanwisher N & Duchaine BC (2007). Can generic expertise explain special processing for faces? Trends Cogn Sci, 11, 8-15.

Megreya AM & Burton AM (2006). Unfamiliar faces are not faces: evidence from a matching task. Mem Cognit, 34, 865-76.

Meyer DE, Irwin DE, Osman AM & Kounios J (1988). The dynamics of cognition and action: mental processes inferred from speed-accuracy decomposition. Psychol Rev, 95, 183-237.

Michel C, Corneille O & Rossion B (2007). Race categorization modulates holistic face encoding. Cogn Sci, 31, 911-24.Michel C, Rossion B, Han J, Chung CS & Caldara R (2006). Holistic processing is finely tuned for faces of one's own race. Psychol Sci, 17, 608-15.

Mondloch C, Pathman T, Maurer D, Le Grand R & de Schonen S (2007). The composite face effect in six-year-old children: Evidence of adult-like holistic face processing. Visual Cognition, 15, 564-577.

O'Donnell C & Bruce V (2001). Familiarisation with faces selectively enhances sensitivity to changes made to the eyes. Perception, 30, 755-764.

Orban de Xivry, J.-J., Ramon, M., Lefèvre, P., Rossion, B. (2008). Reduced fixation on the upper area of personally familiar faces following acquired prosopagnosia. Journal of Neuropsychology, 2, 245-268.

Pachella RG (1974). The interpretation of reaction time in information-processing research. In B. H. Kantowitz (Ed.) Human information processing: Tutorials in performance and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates. Pp. 41-82.

Proietti V, Pisacane A & Macchi Cassia V (2013) Natural Experience Modulates the Processing of Older Adult Faces in Young Adults and 3-Year-Old Children. PLoS ONE 8(2): e57499.

Ramon M (2015). Differential processing of vertical interfeature relations due to real-life experience with personally familiar faces. Perception, 44, 368–382.

Ramon M (2015). Perception of global facial geometry is modulated through experience. PeerJ. 2015 Mar 24;3:e850. doi: 10.7717/peerj.850. eCollection 2015.

Ramon M, Busigny T & Rossion B (2010). Impaired holistic processing of unfamiliar individual faces in acquired prosopagnosia. Neuropsychologia, 48, 933-44.

Ramon M, Busigny T, Gosselin G & Rossion B (in preparation). All new kids on the block? Impairment of holistic processing of personally familiar faces in a kindergarten teacher with acquired prosopagnosia.

Ramon M, Caharel S & Rossion B (2011). The speed of recognition of personally familiar faces. Perception, 40, 437-449.

Ramon M, Dricot L, Rossion B (2010). Personally familiar faces are perceived categorically in face-selective regions other than the fusiform face area. Eur J Neurosci, 32: 1587-98.

Richler JJ & Gauthier I (2013). When intuition fails to align with data: A reply to Rossion (2013). Visual Cognition, 21, 254-276.

Roberts T & Bruce V (1989). Repetition priming of face recognition in a serial choice reaction time task. British Journal of Psychology, 80, 201-11.

Rossion B (2014). Understanding face perception by means of prosopagnosia and neuroimaging. Front Biosci (Elite Ed), Jun 1;6:258-307.

Rossion, B. (2013). The composite face illusion: a whole window into our understanding of holistic face perception. Visual Cognition, 21, 139-253.

Rotshtein P, Henson RN, Treves A, Driver J, Dolan RJ (2005). Morphing Marilyn into Maggie dissociates physical and identity face representations in the brain. Nat Neurosci, 8: 107-13.

Russell R, Sinha P, Biederman I, Nederhouser M (2006). Is pigmentation important for face recognition? Evidence from contrast negation. Perception, 35: 749-59.

Sadr J, Jarudi I & Sinha, P (2003). The role of eyebrows in face recognition. Perception, 32, 285-293.

Schwaninger A, Wallraven C, Cunningham DW & Chiller-Glaus SD (2006). Processing of facial identity and expression: a psychophysical, physiological, and computational perspective. Prog Brain Res, 156, 321-43.

Sergent J (1986). Microgenesis of face perception. In: Aspects of face processing. Eds. Ellis HD, Jeeves MA, Newcombe F, Young AM. Martinus Nijhoff, Dordrecht (1986).

Sergent, J. (1984). An investigation into component and configural processes underlying face perception. British Journal of Psychology, 75, 221-242.

Susilo T, Crookes K, McKone E & Turner H (2009). The composite task reveals stronger holistic processing in children than adults for child faces. PLoS One; 4(7):e6460.

Tanaka, J. W., & Farah, M. J. (2003). The holistic representation of faces. In M. A. Peterson & G. Rhodes (Eds.), Perception of Faces, Objects, and Scenes: Analytic and Holistic Processes (pp. 53-74). New York, NY: Oxford University Press.

Tanaka,J. W., & Farah, M. (1993). Parts and wholes in face recognition. Quarterly Journal of Experimental Psychology, 46, 225-245.

Tong F & Nakayama K (1999). Robust representations for faces: evidence from visual search. J Exp Psychol Hum Percept Perform, 25, 1016-1035.

1   Van Belle G, Busigny T, Lefèvre P, Joubert S, Felician O, Gentile F & Rossion B (2011).

2   Impairment of holistic face percetion following right occipito-temporal damage in

3   prosopagnosia: converging evidence from gaze-contingency. Neuropsychologia, 49, 3145-

4   3150.

5   Van Belle G, De Graef P, Verfaillie K, Busigny T & Rossion B (2010). Whole not hole:

6   expert face recognition requires holistic perception. Neuropsychologia, 48, 2609-2620.

7   Van Belle G, De Graef P, Verfaillie K, Rossion B & Lefèvre P (2010). Face inversion impairs

8   holistic perception: Evidence from gaze-contingent stimulation. Journal of Vision. May

9   1;10. pii: 10.5.10. doi: 10.1167/10.5.10.Van Belle G, Lefèvre P & Rossion B (2012).

10 Reduction of the perceptual field for inverted faces:evidence from gaze contingency with

11 full view stimuli. J Vis, 12(9): 625. doi: 10.1167/12.9.625

12 Van Belle G, Lefèvre P, Laguesse R, Busigny T, De Graef P & Verfaillie K (2010). Feature-

13 based processing of personally familiar faces in prosopagnosia: Evidence from eyegaze

14 contingency. *Behavioural Neurology,* 23, 255-257.

15 Van Belle G, Ramon M, Lefèvre P & Rossion B (2010). Fixation patterns during recognition

16 of personally familiar and unfamiliar faces. Front Psychol. 2010 Jun 17;1:20. doi:

17 10.3389/fpsyg.2010.00020. eCollection 2010.

18 Wang R, Li J, Fang H, Tian M & Liu Jia (2012). Individual Differences in Holistic Processing

19 Predict Face Recognition Ability. Psychological Science, 23, 169-177.

20 Watier NN & Collin CA (2009). Effects of familiarity on spatial frequency thresholds for face

21 matching. Perception, 38, 1497-507.Young AW, Hay DC, McWeeny KH, Flude BM &

22 Ellis AW (1985). Matching familiar and unfamiliar faces on internal and external features.

23 Perception, 14, 737-46.

24

1   **Supplemental material**

2   Table S1 provides the accuracy scores and correct RTs per condition along with 95%

3   bootstrapped confidence intervals. These were obtained per condition and group by randomly

4   sampling subjects with replacement; this process was repeated 999 times, leading to a

5   distribution of bootstrapped estimates of the mean accuracy and RT for each condition.

6   Accuracy scores were considered above chance and below ceiling if the confidence intervals

7   did not contain .5 nor 1, which was the case across groups and experimental conditions.

8   Table S1. Average accuracy scores and RTs in msec along with 95% bootstrap confidence intervals for
9   each condition.

Group	Stimuli	Condition	Accuracy [95% CI]	RTs [95% CI]
Experimental	Familiar	Full 20%	.62 [.57; .67]	1007 [916; 1101]
		Full 50%	.98 [.96; .99]	769 [697; 849]
		Blur 50%	.88 [.81; .94]	856 [811; 902]
	Unfamiliar	Full 20%	0.65 [.58; .72]	1029 [926; 1138]
		Full 50%	.86 [.83; .90]	870 [798; 940]
		Blur 50%	.64 [.58; .70]	863 [797; 936]
Control	Familiar	Full 20%	.77 [.73; .81]	1037 [905; 1184]
		Full 50%	.91 [.87; .94]	870 [751; 1007]
		Blur 50%	0.77 [.72; .81]	894 [783; 1021]
	Unfamiliar	Full 20%	.76 [.71; .81]	975 [803; 1169]
		Full 50%	.89 [.85; .92]	982 [799; 1235]
		Blur 50%	.70 [.64; .76]	974 [833; 1124]