Picture Database of Morphed Faces (MoFa): Technical Report

Theodor Jäger, Kerstin H. Seiler, & Axel Mecklinger

Experimental Neuropsychology Unit, Department of Psychology, Saarland University,

Saarbrücken, Germany

Address correspondence to:

Theodor Jäger

Experimental Neuropsychology Unit

Department of Psychology, Saarland University

D-66123 Saarbrücken, Germany

phone: ++49-681-302-6585

email: s9thjaeg@stud.uni-saarland.de (or k.seiler@mx.uni-saarland.de)

May, 24, 2005

Abstract

In the present study, a morphing and picture processing procedure was used to create a database of 100 face-pairs, which were morphed into one another in steps of 5%. Furthermore, 240 face stimuli were also included that were not morphed but may be used for control purposes. The face stimuli chosen for this database were with minimal or neutral emotional facial expression. In two experiments, selected items of the face stimuli were rated by participants in order to reveal (a) the minimal degree to which a face can be morphed such that a physical change but no identity change is apparent and (b) the degree to which a face needs to be morphed such that the morphed face is perceived as representing a different person than the initial face. The results show that 35% morphed faces mainly seem to fulfill condition (a) while 70% morphed faces mainly fulfill condition (b), especially when outlying morph-pairs are excluded. In conclusion, the present database provides morphed stimulus material that was rated by a moderately large number of participants and may be used for broad experimental purposes.

1. Introduction

Advances in professional photo editing software have given researchers the opportunity to use sophisticated stimulus material in experimental psychology research. For instance, computerized *morphing* procedures have been used to create stimulus materials (see Steyvers, 1999). "Morphing" is an image processing technique used for the metamorphosis from one parent image into another. The idea is to get a sequence of intermediate images which – when put together with the original parent images – would represent the change from one parent image to the other in a gradual way. In typical morphing programs, two parent images are displayed. The program then distorts the parent images so that areas close to a shape in one image move close to its associated shape of the other image resulting in an interpolation of color and shape (see Beale & Keil, 1995).

So far, morphed pictures have been used for investigating the psychological representation of human faces (Busey, 1998), the recognition of morphed faces (Busey & Tunnicliff, 1999), the discriminability of facial changes (Lehky, 2000), categorical effects in the perception of human faces (Beale & Keil, 1995; Campanella, Hanoteau, Seron, Joassin, & Bruyer, 2003) and face gender (Bulthoff & Newell, 2004; Campanella, Chrysochoos, & Bruyer, 2001), brain processes associated with physical changes versus identity changes of faces (Rotshtein, Henson, Treves, Driver, & Dolan, 2005), brain processes associated with self-recognition (Keenan, Nelson, O'Connor, & Pascual-Leone, 2001; Kircher et al., 2001), the processing of facial emotions (Bimler & Kirkland, 2001; Sato & Yoshikawa, 2004; Winston, O'Doherty, & Dolan, 2003), gender differences in the reaction to children's faces (Platek, Burch, Panyavin, Wasserman, & Gallup, 2002; Platek et al., 2004), the perception of faces in clinical populations (Mendez & Lim, 2004; Roesler, Lanquillon, Dippel, & Braune, 1997; Teunisse & Gelder, 2001), the processing of unique versus averaged faces (Bruce, Ness, Hancock, Newman, & Rarity, 2002; Spetch, Cheng, & Clifford, 2004), the processing of own-race versus other-race faces (Corneille, Huart, & Becquart, 2004; Walker & Tanaka,

2003), and even visual categorization in primates (Freedman, Riesenhuber, Poggio, & Miller, 2001, 2003).

However, to the best of our knowledge, there exists no database so far containing a large number of standardized morphed face images rated for physical and/or identity changes. Therefore, the first aim of the present study was to create a database consisting of 100 morphed faces. Moreover, the present database should also include face stimuli that are not morphed but may be used for control purposes. Therefore, the present database should finally consist of 100 morphed and 240 additional faces that are similar to the morphed faces with respect to display window and picture quality. The second aim of the present study was to obtain ratings of the morphed face stimuli from participants in order to reveal (a) to which minimal degree a parent face has to be morphed such that a physical change but no identity change is apparent and (b) to which degree a parent face needs to be morphed such that the morphed face is perceived as representing a different person than the initial parent face. In the following, the morphing procedure as well as the two experiments will be described in detail:

2. Morphing procedure

2.1 Method

2.1.1 Materials

Initial face stimuli. The set of face stimuli consisted of 440 digitized gray-scale portraits of unknown Caucasian people aged approximately 20 to 40 years (50% female, 50% male), which were taken from a picture database consisting of 685 face stimuli. Part of the face stimulus material has been used in Endl et al. (1998). All pictures that were used in this study showed people without distinctive facial features such as beards, spectacles, large proportions of teeth, or conspicuous clothes/hairstyle. Furthermore, for the present purposes, only face stimuli were chosen with neutral or almost neutral emotional expressions.

2.1.2 Procedure

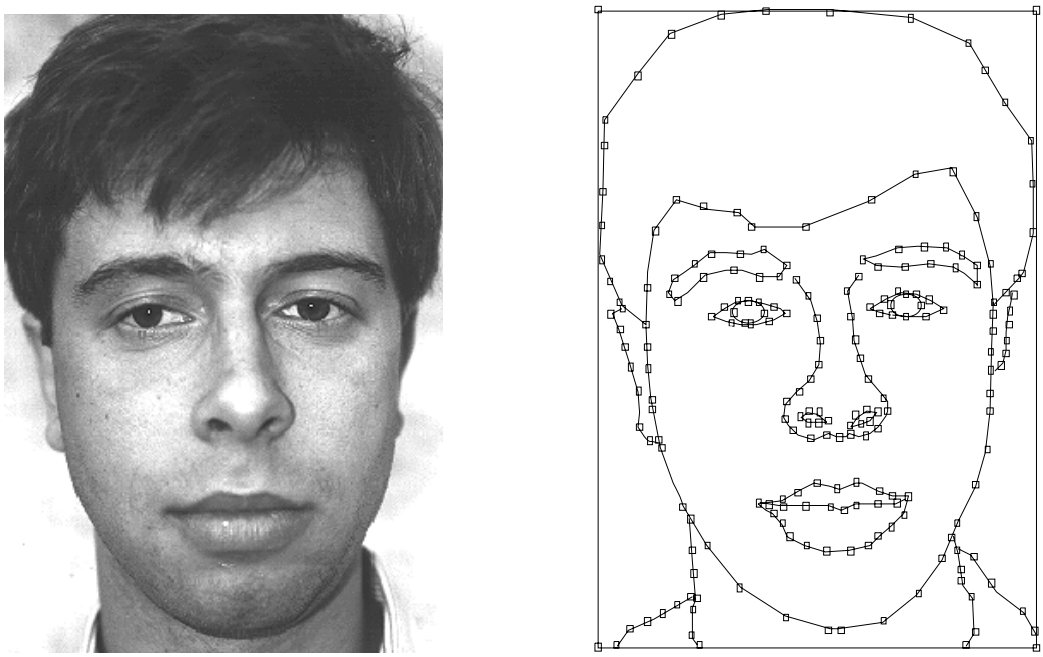
Pre-morphing processing. At first, all 440 face stimuli were rectangularly cut using Adobe Photoshop (version 7.0) such that the faces were located in the center of the picture and contained approximately the same facial features across the stimulus material (the faces were cut just below the chin). Then, all faces were resized to 257 pixels (=8.7 cm) in width and 374 pixels (=12.67 cm) in height, with an image resolution of 75 pixels/inch. After that, 100 face-pairs were formed by randomly selecting the first parent picture and then selecting the second parent picture on the basis of matched gender and composition of the photograph. If the faces of such a face-pair were too similar, it was replaced by another, more dissimilar face-pair in order to ensure significant changes and discriminability of the face stimuli through the morphing procedure. Finally, the pre-morphing database consisted of 100 face-pairs selected for the morphing procedure (i.e., 200 parent face stimuli; 50% female, 50% male) and 240 face stimuli (50% female, 50% male) that were not morphed but may be used for other purposes. These 240 face stimuli that were not morphed are referred to as the "unchanged face stimuli" in the following.

Morphing procedure. The 100 face-pairs were morphed using the software WinMorph (version 3.01; available on http://www.debugmode.com/winmorph/). The algorithm of the morphing software consists of two primary processes (cf. Beale & Keil, 1995): (1) The warping process linearly shifts the marked key features in one of the parent faces to the corresponding key features in the second parent face. For instance, the key features of a 30% morphed face are shifted 30% along the linear path between the initial and the final position of the key features. (2) The fading process gradually transforms the color of corresponding pixels in the two parent images.

One of the most time consuming tasks in morphing is selecting the points in the two parent images so that the metamorphosis is smooth, natural, and shows no distortions. Specifically, to do a morph, we had to draw shapes on the parent images outlining the key

features of the images and associate the shapes on the two parent images with one another (the polyline, rectangle, and ellipse tools of the morphing program were used to draw the shapes and the edit and transform tools were used to manipulate and adjust single shapes). The shapes were designed to mark the following key features of the faces (the approximate number of points that constituted a single shape are listed in parentheses; see also Figure 1): border of the rectangular picture (4), contour of the face (30), hair (20), eyebrow (12 each), eye (10 each), pupil (4 each), nose (24), nasal orifice (7 each), ears (12 each), mouth (20), the fissure between the lips (8), neck (12), and clothes (10; if visible on the images). In sum, these shapes resulted in approximately 218 points that were drawn in each of the parent images of a morph-pair.

Figure 1: Face image and template of morph points used in the morphing procedure.



Note. On the left: A representative face image of a morph-pair that was used as one of the parent pictures. On the right: The shapes marking the key features of the face stimuli and the single points that constitute the shapes. For every face of a morph-pair, approximately 218 points were used to map locations on one face to locations on the other in a one-to-one correspondence.

If necessary, additional shapes were added if the images contained features that were not adequately captured using the initial shapes described above, by this resulting in visible morphing distortions (e.g., blurred spots or face features). Using the preview mode of the morphing software, the morph-process was carefully examined for possible distortions or unsatisfactory morphings and corrections were made in order to obtain satisfactory morph pictures. For every morph-pair, 21 morphed images were rendered (as bitmap-files), such that a symmetrical continuum was obtained that represented gradual transitions from one parent face to the other in steps of 5% (i.e., 0% to 100%). These 21 pictures were again checked for the quality of the obtained morphed face images and, if necessary, distortions were corrected by reforming or adding shapes to the morph-pairs. Finally, if a morph-pair still contained distortions and could not be corrected, it was replaced by another, new pair of parent faces.

Post-morphing processing. After the morphing procedure, all unchanged faces were resized to 257 pixels (=9.07 cm) in width and 379 pixels (=13.37 cm) in height, with an image resolution of 72 pixels/inch, since the morphed faces turned out to have this size as a result of the rendering process. Then, using Adobe Photoshop (version 7.0), the unchanged faces and the morph-degrees of the morph-pairs that were used in Experiment 1 and Experiment 2 (see below) were edited as follows: (1) The faces were cut at the outer contour of the head using smooth borders (2 pixels). (2) The background behind these cut faces was set to a light-grey color (R: 162, G: 162, B: 162). (3) The 0% morph degree faces and the unchanged faces were filtered using a Gauss-filter (radius = 0.5 pixel). Gauss-filtering was necessary to equate the sharpness of the face stimuli because the morphed pictures except the parent faces showed less sharpness than the parent faces and the unchanged faces. Moreover, if necessary, visible distortions in the morphed faces were eliminated using editing tools of Adobe Photoshop.

At the end, the database consisted of 100 morphed face-pairs (50% female, 50% male) created from the initial 200 parent faces, and 240 unchanged face stimuli (50% female, 50% male).

3. Experiment 1

The first experiment was designed (1) to examine if a 30% morphed face is generally perceived as physically different from its parent picture (i.e., the 0% morphed face) and (2) to pilot the degree to which a parent face has to be morphed to meet the constraint that the face is perceived as representing a different person than the initial parent face. To achieve the second goal, we used 50% and 60% morphed faces and examined their probability of being perceived as the same versus a different person relative to the parent face. The choice of the these particular morph-degrees were motivated by previous findings (Beale & Keil, 1995; Rotshtein et al., 2005), which show that the perception of face identity of highly familiar people is "categorical", such that 30% morphed images are still perceived as representing the same person as the initial parent face to a high degree, while 50% or 60% morphed images may already be perceived as representing a different person because of a rapid shift in identity category. However, it may also be expected that the perception of unfamiliar faces may be somewhat less "categorical" than the perception of familiar faces (see Beale & Keil, 1995).

In Experiment 1, participants rated only a small subset of the morphed faces obtained in the morphing procedure. The results from Experiment 1 were then used as input for Experiment 2, in which a larger number of participants rated selected degrees of all 100 morphed face-pairs.

3.1 Method

3.1.1 Participants

Twenty-seven individuals (females = 13) taken from the student population and the University staff from Saarland University participated in Experiment 1. The participants' mean age was 26.3 years (SD = 4.19; range = 21-43).

3.1.2 Materials

Face stimuli. Of the initial 100 morph-pairs, 4 male and 4 female morph-pairs were randomly selected for this experiment. From these 8 morph-pairs, the following morph degrees were presented: 0%, 30%, 50%, and 60%. Additionally, 4 male and 4 female faces were randomly selected from the 240 unchanged face stimuli and each of these 8 faces was randomly assigned to one of the 8 morph-pairs (under the constraint of same gender). In sum, the face stimuli for Experiment 1 consisted of 40 faces (32 morphed faces & 8 unchanged faces) that were equated in size, background color, and picture sharpness. These 40 faces constituted 8 sets (5 pictures/set). Figure 2 depicts an example of a morph-pair including the two parent faces and the 30%, 50%, and 60% morphed faces lying in between the two parent faces.

Figure 2: Example of a morph-pair used in Experiment 1.

Note. From left to right: parent face 1 (0%), 30% morphed face, 50% morphed face, 60% morphed face, and parent face 2 (100%)

Stimulus presentation. The face stimuli were presented on a personal computer using the software E-Prime (Schneider, Eschmann, & Zuccolotto, 2002). The testing session consisted of the presentation of 8 sets; each set was presented 5 times, i.e., the testing session consisted of 40 trials. Each trial was designed as follows. A fixation cross was presented (1000 ms), followed by a blank screen (200 ms). Then, a 0% morph degree face was presented for 1500 ms, followed by a blank screen (200 ms). After that, one of 8 different

grey-scale distracter pictures containing no people (e.g., a building or a computer) was presented in the same size as the face pictures (1500 ms), followed by a blank screen (200 ms). Then, a second face picture was presented (300 ms), which was randomly chosen from the 5 pictures of a given set, i.e., it was either a repetition of the 0% parent face, the 30% morphed face associated with the parent face, the 50% morphed face, the 60% morphed face, or the unchanged face previously assigned to the given set. After a blank screen of 200 ms, the first judgment was presented to the participant, i.e., the question "Same picture?" appeared on the screen and the participant was required to do the physical judgment (see below). The participants had infinite time to do their judgment by pressing a key on the keyboard (response collection started at the beginning of the presentation of the second face picture). After a response was made, a blank screen (200 ms) was followed by the second judgment, i.e., the question "Same person" appeared on the screen and the participant was required to do the identity judgment (see below). Participants again had infinite time to do their judgment. After a response was made, the next set was presented. The sets were presented in fixed order (male and female sets alternating), while the second face picture of a set was randomly chosen from the 5 face stimuli of a given set. Thus, each set occurred 5 times (such that every of the 5 pictures of a set appeared once as the second face picture), resulting in a total of 40 trials.

3.1.3 Procedure

Each participant was tested individually in a session lasting approximately 15 minutes. At first, participants were given the instructions for the rating. They were explained that they would see a face picture, followed by a picture taken from everyday life, followed by a second face picture. Participants were required (1) to judge if the second face picture was physically identical to the first face picture ("Same picture?") by pressing the "j"-key (= "Yes") and the "f"-key (= "No") on the computer keyboard and (2) to judge if the second face

picture represented the same person as the first face picture ("Same person?") by pressing the same keys as in the physical judgment.

Following the instruction, the experimenter encouraged the participants to ask questions and potential misunderstandings were clarified. Thereafter, the experimenter started the testing session. At the end of the session, the participants were debriefed and thanked for their participation.

3.2 Results

To examine the participants' physical judgments and identity judgments, we calculated the proportion of participants that responded "yes" in the physical and the identity judgment, respectively (i.e., P_1 and P_2; see Table 1 in the Appendix). Additionally, responses in the identity judgment were also calculated for accurate responses in the previous physical judgment, i.e., under the constraint that a "no"-response was made in the physical judgment to the 30%, 50%, and 60% morphed faces and the unchanged faces (i.e., P_3; see Table 1), and the number of cases is delivered for these identity judgments (i.e., n_1; see Table 1). Table 1 shows the results examining every morph-pair separately and the results collapsed across all morph-pairs.

3.3 Discussion

Experiment 1 was designed (1) to examine whether or not a 30% morphed face is generally perceived as physically different from its parent picture (i.e., from the 0% morphed picture) and (2) to examine the degree to which a parent face needs to be morphed under the constraint that the face is perceived as representing a different person as the initial parent face.

The results from Experiment 1 show that participants were accurate in observing that a picture is repeated, which is reflected in 91% "yes"-responses in the physical judgment of physically identical pictures. Moreover, two physically identical pictures were correctly

recognized as representing the same person (i.e., 99% "yes"-responses in the identity judgment). More importantly, physical judgments concerning the 30% morphed faces turned out to be quite difficult, since as much as 55% "yes"-responses occurred in the physical judgment. This result was somewhat surprising because one might have had expected better discrimination of physically identical repetitions from the presentation of 30% morphed pictures after a parent face was shown. Regarding the identity judgment, a high proportion of participants judged the 30% morphed faces as representing the same person as the 0% parent faces (i.e., 96% "yes"-responses). Examinations of the 50% and the 60% morphed faces revealed that physical judgments were very accurate, i.e., participants were able to perceive the morphed faces as physically changed. However, to an unexpectedly high degree, these morphed faces were still perceived as representing the same person as the 0% parent faces (50% morphed faces: 79% "yes"-responses in identity judgment; 60% morphed faces: 64% "yes"-responses in identity judgment). By contrast, presenting pictures showing completely new persons after the presentation of a 0% parent face resulted in highly accurate responses: only 1% "yes"-responses and only 7% "yes"-responses occurred in the physical judgment and in the identity judgment, respectively. Importantly, investigating the identity judgments under the constraint of accurate physical judgment (i.e., $P_{3;}$ see Table 1) yielded approximately the same results.

In sum, Experiment 1 revealed important results for designing Experiment 2, in which participants were required to rate selected degrees of all morphed face-pairs obtained in the morphing procedure.

4. Experiment 2

Experiment 2 was designed to rate all the pictures that were obtained through the morphing procedure. In this experiment, we chose to present participants with parent faces followed by (1) 0% morphed faces, (2) 35% morphed faces, (3) 70% morphed faces, and (4) completely

new faces. The 35% morph-degree was chosen because Experiment 1 showed that physical discriminability of the 30% morphed faces from their parent faces may be too difficult. The 70% morph-degree was chosen because the 50% and 60% morphed-faces in Experiment 1 were still perceived as representing the same person as their parent faces to a degree that was too high for our purposes.

We hypothesized that (a) the 35% morphed faces should consistently be judged as representing the same person as the parent faces in concert with being judged as physically different from the parent faces, and (b) we hypothesized that the 70% morphed faces should consistently be judged as representing a different person as the parent faces in concert with being judged as physically different from the parent faces.

As an additional aspect of Experiment 2, the results would reveal morph-pairs that differ substantially from the majority of the morph-pairs in the way they are perceived. By this means, these outlying morph-pairs can be excluded from further experiments using the morphed faces from the present database.

4.1 Method

4.1.1 Participants

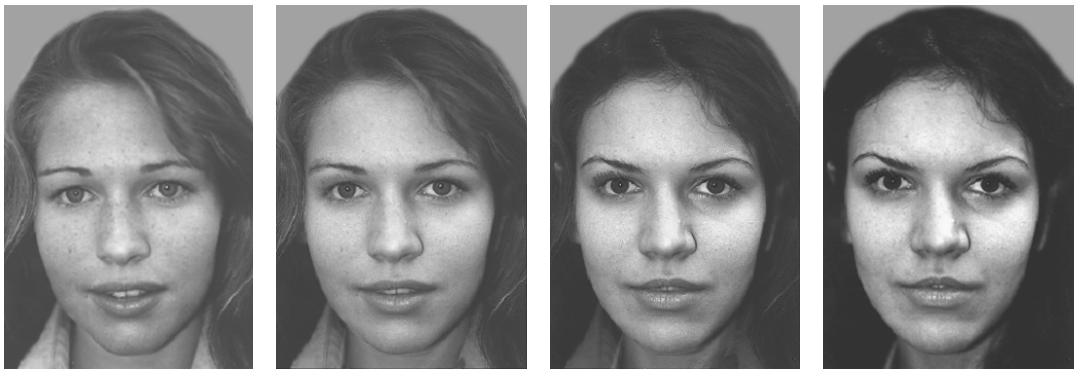
Fifty-five participants (females = 41) taken from the Saarland University undergraduate student population participated in Experiment 2. Forty-five participants completed both testing sessions, while 9 and 1 participants completed only the first or the second session, respectively. The participants' mean age was 23.6 years (*SD* = 5.39; range = 19-44). The participants received course credits for their participation.

4.1.2 Materials

Face stimuli. All 100 morph-pairs that were obtained through the morphing procedure were presented in Experiment 2 (50 female & 50 male morph-pairs). From the initial 21

morph-degrees (representing changes of 5%), the following morph-degrees were used: 0%, 35%, and 70%. Additionally, 50 male and 50 female faces were randomly selected from the 240 unchanged face stimuli and each of these 100 faces was randomly assigned to one of the 100 morph-pairs (under the constraint of same gender). In sum, the face stimuli consisted of 400 faces (300 morphed faces and 100 unchanged faces) that were equated in size, background color, and picture sharpness. These 400 faces consisted of 100 sets (4 pictures/set). Figure 3 depicts an example of a morph-pair including the two parent faces and the 35% and 70% morphed faces lying in between the two parent faces.

Figure 3: Example of a morph-pair used in Experiment 2.



Note. From left to right: parent face 1 (0%), 35% morphed face, 70% morphed face, and parent face 2 (100%)

Stimulus presentation. The face stimuli were presented on the wall of a lecture room by connecting a laptop computer to a beamer. The software E-Prime (Schneider, et al., 2002) was used for stimulus presentation. The testing session consisted of 400 trials (i.e., 100 sets were presented 4 times each). Each trial was designed as follows. A trial-number was presented (1500 ms), followed by a blank screen (200 ms). Then, a 0% morphed face was presented for 1500 ms, followed by a blank screen (200 ms). After that, one of 7 different grey-scale distracter pictures containing no people (e.g., a building or a computer) was presented in the same size as the face pictures (1500 ms), followed by a blank screen (200

ms). Then, a second face picture was presented (300 ms), which was randomly chosen from the 4 pictures of a given set, i.e., it was either a repetition of the 0% parent face, the 35% morphed face associated with the 0% parent face, the 70% morphed face, or the unchanged face previously assigned to the given set. After the presentation of the second face, the sentences “Same picture?” and “Same person?” were presented simultaneously for 4000 ms in order to give the participants time to note down their responses to the physical judgment and the identity judgment on an answer sheet (see below). After that, the next set was presented. The sets were presented in random order with the constraint that a specific set (i.e., one of the 100 morph-pairs) did not appear consecutively.

4.1.3 Procedure

There were two testing sessions (each lasting approximately 40 minutes) that were performed in a group administration form. The sessions were performed in a lecture room and were one week apart. At first, participants were given the instructions for the rating. They were instructed that they would see a face picture, followed by a picture taken from everyday life (e.g., a building or a computer), followed by a second face picture. Participants were required (1) to judge if the second face picture was physically identical to the first face picture (“Same picture?”) and (2) to judge if the second face picture showed the same person as the first face picture (“Same person?”). Participants responded by ticking off the “yes”-response or the “no”-response on an answer sheet (see Appendix). Following the instruction, the experimenter encouraged the participants to ask questions and all misunderstandings were explained. After that, the experimenter started the testing session. Each of the two testing sessions consisted of 200 trials, i.e., a total of 400 trials were performed across both testing sessions.

4.2 Results

Missing values. At first, an analysis of missing values was aimed at investigating if participants systematically gave no answer to specific pictures. This analysis revealed that there were virtually no missing values, and furthermore, there was not any single trial in which more than one participant failed to give an answer.

Physical and identity judgment. To examine the participants' physical judgments and identity judgments, we calculated the proportion of participants that responded "yes" in the physical and the identity judgment, respectively (i.e., P_1 and P_2; see Table 2 in the Appendix). Additionally, responses in the identity judgment were also calculated for accurate responses in the previous physical judgment, i.e., under the constraint that a "no"-response was made in the physical judgment to the 35% morphed faces, the 70% morphed faces and the unchanged faces (i.e., P_3; see Table 2), and the number of cases is delivered for these identity judgments (i.e., n_1; see Table 2). Table 2 shows the results examining every morph-pair separately and the results collapsed across all morph-pairs.

4.3. Exclusion of morph-pairs.

Based on the obtained ratings, one might exclude specific morph-pairs in order to satisfy one's purposes in a given study. However, which morph-pairs to exclude depends entirely on these purposes. In order to meet the criteria of an ERP study to be conducted in our lab, we chose to exclude 20 (50% female, 50% male) of the initial 100 morph-pairs in order to increase homogeneity across the face stimuli. Morph-pairs were excluded if (1) physical discriminability of a 35% morphed face from its parent face was too low (i.e., too high proportion of "yes"-responses in the physical judgment), if (2) a 35% morphed face was rated as representing the same person as its parent face only to a low degree (i.e., too low proportion of "yes"-responses in the identity judgment), or if (3) a 70% morphed face was rated as representing the same person as its parent face to a too high degree (i.e., too high

proportion of "yes"-responses in the identity judgment). A deviation of more than two standard deviations from the mean was applied as rule for which morph-pairs should be excluded. In cases in which the decision about the exclusion was difficult between several possible morph-pairs, morph-pairs were excluded that fulfilled more than one exclusion criterion.

Finally, the following 10 male morph-pairs (m04, m05, m07, m08, m15, m32, m33, m39, m41, & m48) and 10 female morph-pairs (w02, w10, w17, w32, w34, w37, w38, w43, w47, & w48) were thus excluded by these criteria resulting in a database of 80 morph-pairs (50% female, 50% male) and an additional 240 unchanged faces (50% female, 50% male) that were used for our purposes. Table 3 (see in the Appendix) shows the results for the physical and identity judgments, collapsed across these 80 morph-pairs. Compared to the initial 100 morph-pairs (see Table 2), these 80 morph-pairs showed smaller standard deviations and ranges especially for both the physical and the identity judgment concerning the 35% morphed faces and the identity judgment concerning the 70% morphed faces (see Table 3). In detail, the proportion of "yes"-responses in the physical judgment for 35% morphed faces decreased from .34 (.17) to .31 (.14). The proportion of "yes" responses in the identity judgments for 35% morphed faces increased from .86 (.10) to .88 (.08) for P_3 and finally the proportion of "yes"-responses for identity for the 70% faces dropped from .18 (.15) to .16 (.12) for P_3 (standard deviations are given in parentheses).

4.4 Discussion

Experiment 2 aimed at obtaining ratings for 35% morphed faces and 70% morphed faces. We hypothesized that (a) the 35% morphed faces should consistently be judged as representing the same person as the parent faces in concert with being judged as physically different from the parent faces, and (b) we hypothesized that the 70% morphed faces should consistently be judged as representing a different person as the parent faces in concert with being judged as

physically different from the parent faces.

The results from Experiment 2 (for all 100 morph-pairs) show that participants were accurate in observing that a picture is repeated, which is reflected in 92% "yes"-responses in the physical judgment of physically identical pictures. Moreover, two physically identical pictures were correctly recognized as representing the same person (i.e., 99% "yes"-responses in the identity judgment). More importantly, physical judgments concerning the 35% morphed faces turned out to be better relative to the 30% morphed faces from Experiment 1, since only 34% "yes"-responses occurred in the physical judgment showing moderately good physical discriminability of the 35% morphed faces from their parent faces. Regarding the identity judgment, a high proportion of participants judged the 35% morphed faces as representing the same person as the 0% parent faces (i.e., 91% "yes"-responses), which is similar to the 30% morphed faces in Experiment 1. Examinations of the 70% morphed faces revealed that physical judgments were very accurate, i.e., participants were able to perceive the morphed faces as physically changed. Furthermore, the 70% morphed faces were judged as representing the same person as the parent faces only to a moderately high degree (i.e., 20% "yes"-responses), a degree that is substantially smaller relative to the identity judgments to the 50% and 60% morphed faces in Experiment 1. Finally, presenting pictures showing completely new persons after the presentation of a 0% parent face resulted in highly accurate responses: only 1% "yes"-responses and only 4% "yes"-responses occurred in the physical judgment and in the identity judgment, respectively. Importantly, investigating the identity judgments under the constraint of accurate physical judgment (i.e., P_3; see Tables 2 & 3) yielded approximately the same results.

The present experiments also complement the findings from other studies that investigated perceived identity changes in morphed faces (Beale & Keil, 1995; Rotshtein et al., 2005). The results of our study seem to be fully consistent with the view that the perception of familiar faces is more "categorical" than the perception of unfamiliar faces (see

Beale & Keil, 1995; Rotshtein et al., 2005), since across both of our experiments, the decrease in judging unfamiliar morphed faces as representing the same person as their initial parent faces seemed to be more linear than the decrease in identity judgments found by Rotshtein et al. (2005) for highly familiar faces (cf. also Beale & Keil, 1995).

As an additional aspect of Experiment 2 of the present study, the results may also help to exclude specific morph-pairs in order to satisfy one's purposes in a given study. In the Results section, our criteria for a possible exclusion of particular morph-pairs are provided. Depending on the purpose of a study, other criteria are conceivable and can easily be applied. We described the exclusion of 20 morph-pairs in order to prepare the face stimuli to be used in an ERP study to be conducted in our lab. Excluding these 20 morph-pairs clearly resulted in more homogeneous stimulus materials, especially with regard to the 35% and 70% morphed faces (see Table 3).

In conclusion, the present database provides morphed stimulus material that was rated in two experiments and may be used for broad purposes in psychological research.

5. Acknowledgments

We are grateful to Stephan Boehm, who is now at Northwestern University for providing us with the initial face stimuli that were used for creating the present database. We would like to thank Jessika Bodo and Phil Wieland for their helpful assistance in the face stimuli preparation and the data collection.

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7. Appendix

Example of the answer sheet used in Experiment 2.

Item-Nr. *(item-nr.)*	Selbes Foto? *(same picture?)*		Selbe Person? *(same person?)*	
042	□ ja *(yes)*	□ nein *(no)*	□ ja	□ nein
043	□ ja	□ nein	□ ja	□ nein
044	□ ja	□ nein	□ ja	□ nein
045	□ ja	□ nein	□ ja	□ nein
046	□ ja	□ nein	□ ja	□ nein
047	□ ja	□ nein	□ ja	□ nein
048	□ ja	□ nein	□ ja	□ nein
049	□ ja	□ nein	□ ja	□ nein
050	□ ja	□ nein	□ ja	□ nein
051	□ ja	□ nein	□ ja	□ nein
052	□ ja	□ nein	□ ja	□ nein
053	□ ja	□ nein	□ ja	□ nein
054	□ ja	□ nein	□ ja	□ nein
055	□ ja	□ nein	□ ja	□ nein
056	□ ja	□ nein	□ ja	□ nein
057	□ ja	□ nein	□ ja	□ nein
058	□ ja	□ nein	□ ja	□ nein
059	□ ja	□ nein	□ ja	□ nein
060	□ ja	□ nein	□ ja	□ nein

Table 1.

Results of Experiment 1 with $n = 27$.

Morph-Pair	Morph-Degree	P_1: P("Yes") in Physical Judgment	P_2: P("Yes") in Identity Judgment	P_3: P("Yes") in Identity Judgment After "No"-Answer in Physical Judgment[a]	n_1 for P_3 (out of 27)[a]
m01	0%	.96	1.00	--	--
	30%	.48	.93	.86	14
	50%	.11	.78	.75	24
	60%	.07	.74	.76	25
	new face	.00	.07	.07	27
m02	0%	.93	.96	--	--
	30%	.70	1.00	1.00	8
	50%	.07	.89	.88	25
	60%	.04	.63	.62	26
	new face	.00	.04	.04	27
m03	0%	1.00	1.00	--	--
	30%	.33	.89	.89	18
	50%	.11	.59	.63	24
	60%	.04	.26	.27	26
	new face	.00	.04	.04	27
m04	0%	.93	1.00	--	--
	30%	.70	.96	.88	8
	50%	.19	.96	.95	22
	60%	.07	.78	.76	25
	new face	.00	.22	.22	27

w01	0%	.85	.96	--	--
	30%	.37	.96	.94	17
	50%	.07	.59	.60	25
	60%	.07	.48	.44	25
	new face	.04	.11	.12	26
w02	0%	.93	1.00	--	--
	30%	.78	1.00	1.00	6
	50%	.11	.78	.79	24
	60%	.11	.67	.67	24
	new face	.00	.04	.04	27
w03	0%	.82	1.00	--	--
	30%	.44	.96	.93	15
	50%	.14	.78	.78	23
	60%	.11	.82	.83	24
	new face	.00	.00	.00	27
w04	0%	.82	1.00	--	--
	30%	.63	.96	.90	10
	50%	.30	.96	.95	19
	60%	.15	.70	.65	23
	new face	.00	.07	.07	27

Morph-Pair	Morph-Degree	P_1: P("Yes") in Physical Judgment	P_2: P("Yes") in Identity Judgment	P_3: P("Yes") in Identity Judgment After "No"-Answer in Physical Judgment[a]	n_1 for P_3 (out of 27)[a]
M	**0%**	**.91**	**.99**	**--**	**--**
M	**30%**	**.55**	**.96**	**.93**	**12.0**
M	**50%**	**.14**	**.79**	**.79**	**23.3**
M	**60%**	**.08**	**.64**	**.63**	**24.8**
M	**new face**	**.01**	**.07**	**.08**	**26.9**

Note [a] n_1 includes all participants that responded "no" in the physical judgment (irrespective of subsequent response in the identity judgment) and P_3 represents the proportion of these participants that subsequently responded "yes" in the identity judgment.

The "m" and the "w" in the names of the morph-pairs indicate the gender of the face stimuli ("m" = male; "w" = female).

Table 2.

Results of Experiment 2 with $n = 55$ (across all 100 morph-pairs).

Morph-Pair	Morph-Degree	P_1: P("Yes") in Physical Judgment	P_2: P("Yes") in Identity Judgment	P_3: P("Yes") in Identity Judgment After "No"-Answer in Physical Judgment[a]	n_1 for P_3[a]
m01	0%	.91	.96	--	--
	35%	.26	.93	.91	34
	70%	.06	.45	.42	50
	new face	.00	.11	.11	53
m02	0%	.93	1.00	--	--
	35%	.28	.98	.97	33
	70%	.00	.26	.26	46
	new face	.02	.06	.04	52
m03	0%	.91	.98	--	--
	35%	.34	.94	.91	35
	70%	.00	.00	.00	46
	new face	.00	.00	.00	46
m04	0%	.94	1.00	--	--
	35%	.47	.98	.96	24
	70%	.02	.41	.40	45
	new face	.00	.02	.02	53
m05	0%	.98	1.00	--	--
	35%	.11	.60	.55	47
	70%	.00	.00	.00	46
	new face	.02	.42	.40	52

m06	0%	.98	1.00	--	--
	35%	.53	1.00	1.00	21
	70%	.02	.40	.39	44
	new face	.02	.04	.02	45
m07	0%	.93	1.00	--	--
	35%	.37	.98	.97	29
	70%	.02	.53	.52	52
	new face	.02	.00	.00	44
m08	0%	.87	.98	--	--
	35%	.63	.98	.94	17
	70%	.04	.20	.16	44
	new face	.00	.04	.04	52
m09	0%	1.00	1.00	--	--
	35%	.13	.96	.95	40
	70%	.00	.09	.09	53
	new face	.00	.00	.00	45
m10	0%	.81	.94	--	--
	35%	.52	1.00	1.00	22
	70%	.04	.17	.14	51
	new face	.02	.07	.04	45
m11	0%	.90	.96	--	--
	35%	.24	.82	.76	34
	70%	.02	.04	.02	52
	new face	.04	.04	.00	51
m12	0%	.91	1.00	--	--
	35%	.15	.81	.78	45
	70%	.06	.08	.02	50
	new face	.00	.00	.00	46

m13	0%	1.00	1.00	--	--
	35%	.11	.78	.76	41
	70%	.00	.04	.04	46
	new face	.00	.00	.00	53
m14	0%	.93	.98	--	--
	35%	.46	.96	.92	25
	70%	.00	.09	.09	46
	new face	.02	.02	.00	45
m15	0%	1.00	1.00	--	--
	35%	.08	.49	.47	49
	70%	.00	.02	.02	53
	new face	.04	.04	.00	51
m16	0%	.93	1.00	--	--
	35%	.19	.90	.88	42
	70%	.00	.09	.09	53
	new face	.06	.06	.02	50
m17	0%	.87	.98	--	--
	35%	.24	.93	.91	35
	70%	.04	.19	.16	51
	new face	.00	.00	.00	46
m18	0%	1.00	1.00	--	--
	35%	.28	.81	.74	38
	70%	.02	.17	.15	52
	new face	.00	.17	.17	46
m19	0%	.98	1.00	--	--
	35%	.36	.94	.91	34
	70%	.06	.23	.20	50
	new face	.06	.08	.04	50

m20	0%	.96	1.00	--	--
	35%	.39	.96	.93	28
	70%	.00	.08	.08	53
	new face	.02	.00	.00	52
m21	0%	.89	.98	--	--
	35%	.43	.91	.85	26
	70%	.02	.13	.12	52
	new face	.06	.09	.04	50
m22	0%	.98	1.00	--	--
	35%	.36	.87	.79	34
	70%	.00	.07	.07	46
	new face	.00	.04	.04	53
m23	0%	.96	1.00	--	--
	35%	.41	.89	.81	27
	70%	.02	.33	.31	45
	new face	.00	.00	.00	53
m24	0%	.90	.96	--	--
	35%	.37	.96	.93	29
	70%	.00	.04	.04	53
	new face	.04	.04	.00	51
m25	0%	.98	1.00	--	--
	35%	.22	.91	.89	36
	70%	.02	.08	.08	52
	new face	.00	.00	.00	46
m26	0%	.92	.96	--	--
	35%	.43	.91	.87	30
	70%	.00	.04	.04	46
	new face	.04	.04	.00	51

m27	0%	.98	1.00	--	--
	35%	.23	.85	.80	41
	70%	.00	.21	.21	53
	new face	.00	.02	.02	53
m28	0%	.93	1.00	--	--
	35%	.22	.83	.78	36
	70%	.02	.08	.06	52
	new face	.02	.06	.04	52
m29	0%	.89	.98	--	--
	35%	.28	.91	.88	33
	70%	.00	.02	.02	53
	new face	.00	.17	.17	53
m30	0%	1.00	1.00	--	--
	35%	.47	.92	.86	28
	70%	.02	.37	.36	45
	new face	.00	.02	.02	53
m31	0%	.96	1.00	--	--
	35%	.23	.83	.78	41
	70%	.00	.08	.08	53
	new face	.00	.02	.02	53
m32	0%	.91	1.00	--	--
	35%	.57	.96	.91	23
	70%	.02	.34	.33	52
	new face	.00	.00	.00	53
m33	0%	.96	1.00	--	--
	35%	.68	.98	.94	17
	70%	.06	.43	.40	50
	new face	.02	.08	.06	52

m34	0%	.98	.98	--	--
	35%	.15	.94	.93	45
	70%	.02	.42	.40	52
	new face	.02	.04	.02	52
m35	0%	.91	1.00	--	--
	35%	.46	.89	.80	25
	70%	.00	.04	.04	46
	new face	.00	.02	.02	46
m36	0%	1.00	1.00	--	--
	35%	.42	.98	.97	31
	70%	.02	.21	.19	52
	new face	.02	.02	.00	52
m37	0%	.93	.98	--	--
	35%	.30	.92	.89	37
	70%	.04	.38	.35	43
	new face	.02	.02	.00	45
m38	0%	.91	1.00	--	--
	35%	.54	1.00	1.00	21
	70%	.00	.36	.36	53
	new face	.00	.02	.02	46
m39	0%	.85	.98	--	--
	35%	.50	.92	.85	26
	70%	.04	.46	.43	44
	new face	.00	.00	.00	46
m40	0%	.89	.96	--	--
	35%	.43	.96	.93	30
	70%	.00	.15	.15	53
	new face	.00	.00	.00	46

m41	0%	.89	.98	--	--
	35%	.57	.96	.91	23
	70%	.07	.54	.52	43
	new face	.00	.00	.00	45
m42	0%	.91	.98	--	--
	35%	.41	.96	.93	27
	70%	.00	.00	.00	46
	new face	.02	.08	.06	52
m43	0%	.91	1.00	--	--
	35%	.23	.81	.75	40
	70%	.04	.07	.02	44
	new face	.00	.02	.02	53
m44	0%	.89	1.00	--	--
	35%	.09	.72	.69	42
	70%	.02	.11	.09	45
	new face	.00	.21	.21	53
m45	0%	.87	1.00	--	--
	35%	.41	.96	.93	27
	70%	.02	.15	.13	45
	new face	.02	.02	.00	52
m46	0%	.83	.96	--	--
	35%	.28	.89	.84	38
	70%	.00	.08	.08	53
	new face	.00	.02	.02	52
m47	0%	1.00	1.00	--	--
	35%	.49	.94	.89	27
	70%	.04	.06	.02	51
	new face	.02	.04	.02	45

m48	0%	.94	1.00	--	--
	35%	.64	.94	.84	19
	70%	.02	.06	.04	51
	new face	.00	.00	.00	46
m49	0%	.96	.98	--	--
	35%	.23	.93	.90	41
	70%	.00	.13	.13	53
	new face	.00	.04	.04	46
m50	0%	.76	1.00	--	--
	35%	.46	.98	.96	25
	70%	.06	.42	.38	50
	new face	.02	.06	.04	52
w01	0%	.93	1.00	--	--
	35%	.39	.98	.96	28
	70%	.00	.20	.20	46
	new face	.00	.00	.00	46
w02	0%	.90	1.00	--	--
	35%	.49	.94	.89	27
	70%	.00	.49	.49	53
	new face	.00	.00	.00	46
w03	0%	.92	.96	--	--
	35%	.33	.93	.90	31
	70%	.02	.43	.42	45
	new face	.00	.00	.00	53
w04	0%	.89	.96	--	--
	35%	.61	.98	.94	18
	70%	.00	.32	.32	53
	new face	.00	.00	.00	53

w05	0%	.94	.96	--	--
	35%	.50	.96	.91	23
	70%	.00	.04	.04	46
	new face	.00	.04	.04	46
w06	0%	.94	1.00	--	--
	35%	.00	.83	.83	46
	70%	.02	.07	.04	45
	new face	.00	.09	.09	53
w07	0%	.87	.98	--	--
	35%	.17	.89	.87	38
	70%	.02	.11	.10	52
	new face	.00	.00	.00	46
w08	0%	.96	1.00	--	--
	35%	.37	.93	.90	29
	70%	.00	.17	.17	53
	new face	.00	.02	.02	53
w09	0%	.93	1.00	--	--
	35%	.43	.93	.88	26
	70%	.00	.13	.13	46
	new face	.02	.04	.02	45
w10	0%	.92	1.00	--	--
	35%	.62	.94	.85	20
	70%	.02	.07	.04	45
	new face	.00	.11	.11	53
w11	0%	.87	1.00	--	--
	35%	.13	.80	.78	40
	70%	.00	.02	.02	46
	new face	.02	.02	.00	45

w12	0%	.89	1.00	--	--
	35%	.53	.94	.88	25
	70%	.04	.08	.04	50
	new face	.00	.11	.11	53
w13	0%	.89	.98	--	--
	35%	.52	1.00	1.00	22
	70%	.02	.21	.19	52
	new face	.00	.04	.04	53
w14	0%	.89	.98	--	--
	35%	.09	.83	.81	48
	70%	.00	.15	.15	53
	new face	.00	.02	.02	53
w15	0%	.93	.98	--	--
	35%	.30	.98	.97	32
	70%	.00	.07	.07	46
	new face	.00	.02	.02	53
w16	0%	.94	1.00	--	--
	35%	.28	.89	.84	38
	70%	.02	.34	.33	52
	new face	.00	.00	.00	46
w17	0%	.94	.96	--	--
	35%	.85	1.00	1.00	8
	70%	.02	.32	.31	52
	new face	.00	.00	.00	46
w18	0%	.92	.94	--	--
	35%	.33	.98	.97	31
	70%	.04	.13	.12	51
	new face	.04	.09	.08	51

w19	0%	.93	.98	--	--
	35%	.26	.93	.91	34
	70%	.02	.20	.18	45
	new face	.00	.04	.04	46
w20	0%	.98	1.00	--	--
	35%	.30	1.00	1.00	32
	70%	.00	.04	.04	53
	new face	.00	.00	.00	46
w21	0%	.91	.96	--	--
	35%	.54	.98	.95	21
	70%	.00	.26	.24	45
	new face	.02	.06	.06	51
w22	0%	.83	1.00	--	--
	35%	.28	.91	.88	33
	70%	.00	.00	.00	46
	new face	.00	.00	.00	53
w23	0%	.91	.96	--	--
	35%	.32	.92	.89	36
	70%	.00	.17	.17	46
	new face	.00	.00	.00	53
w24	0%	.92	1.00	--	--
	35%	.49	.98	.96	27
	70%	.02	.15	.13	52
	new face	.00	.02	.02	53
w25	0%	.79	.96	--	--
	35%	.08	.75	.73	49
	70%	.00	.02	.02	45
	new face	.00	.07	.07	46

w26	0%	.93	.98	--	--
	35%	.46	.93	.88	25
	70%	.02	.17	.17	52
	new face	.00	.00	.00	46
w27	0%	.91	1.00	--	--
	35%	.02	.76	.76	45
	70%	.00	.04	.04	46
	new face	.00	.00	.00	46
w28	0%	.91	.98	--	--
	35%	.13	.75	.72	46
	70%	.00	.11	.11	53
	new face	.00	.08	.08	53
w29	0%	.96	1.00	--	--
	35%	.20	.98	.97	37
	70%	.00	.09	.09	53
	new face	.02	.02	.00	45
w30	0%	.96	1.00	--	--
	35%	.22	1.00	1.00	36
	70%	.00	.47	.47	53
	new face	.00	.08	.08	53
w31	0%	.94	1.00	--	--
	35%	.28	.89	.85	33
	70%	.00	.24	.24	46
	new face	.00	.00	.00	46
w32	0%	1.00	1.00	--	--
	35%	.63	.98	.94	17
	70%	.04	.17	.14	51
	new face	.00	.00	.00	46

w33	0%	.94	.94	--	--
	35%	.21	.85	.81	42
	70%	.02	.40	.38	52
	new face	.00	.02	.02	46
w34	0%	.93	1.00	--	--
	35%	.42	.91	.84	31
	70%	.02	.54	.53	45
	new face	.00	.00	.00	53
w35	0%	.92	1.00	--	--
	35%	.33	.96	.94	31
	70%	.00	.15	.15	46
	new face	.00	.00	.00	45
w36	0%	.93	1.00	--	--
	35%	.17	.98	.97	38
	70%	.06	.38	.34	50
	new face	.00	.00	.00	53
w37	0%	.87	.94	--	--
	35%	.04	.63	.61	44
	70%	.00	.02	.02	46
	new face	.00	.04	.04	46
w38	0%	.94	.96	--	--
	35%	.66	.92	.78	18
	70%	.00	.54	.54	46
	new face	.02	.15	.13	52
w39	0%	.89	1.00	--	--
	35%	.19	.77	.72	43
	70%	.04	.21	.20	51
	new face	.02	.02	.00	45

w40	0%	.96	1.00	--	--
	35%	.07	.85	.84	43
	70%	.02	.17	.16	45
	new face	.00	.00	.00	46
w41	0%	.83	.98	--	--
	35%	.24	.89	.86	35
	70%	.02	.15	.13	52
	new face	.00	.00	.00	53
w42	0%	.96	1.00	--	--
	35%	.15	.93	.92	39
	70%	.02	.19	.17	52
	new face	.00	.00	.00	46
w43	0%	.93	.98	--	--
	35%	.35	1.00	1.00	30
	70%	.04	.50	.48	44
	new face	.00	.04	.04	53
w44	0%	.89	1.00	--	--
	35%	.47	1.00	1.00	28
	70%	.00	.26	.26	53
	new face	.00	.00	.00	46
w45	0%	.96	1.00	--	--
	35%	.30	.89	.84	37
	70%	.00	.17	.17	46
	new face	.00	.02	.02	46
w46	0%	.96	1.00	--	--
	35%	.26	.89	.85	34
	70%	.00	.17	.17	46
	new face	.00	.00	.00	46

w47	0%	.91	.98	--	--
	35%	.38	.79	.67	33
	70%	.00	.02	.02	46
	new face	.00	.11	.11	46
w48	0%	.91	1.00	--	--
	35%	.08	.75	.73	49
	70%	.00	.09	.09	46
	new face	.00	.00	.00	46
w49	0%	.94	1.00	--	--
	35%	.13	.93	.93	40
	70%	.02	.35	.33	45
	new face	.00	.17	.17	53
w50	0%	.91	1.00	--	--
	35%	.50	1.00	1.00	23
	70%	.02	.38	.37	51
	new face	.00	.00	.00	46

Morph-Pair	Morph-Degree	P_1: P("Yes") in Physical Judgment	P_2: P("Yes") in Identity Judgment	P_3: P("Yes") in Identity Judgment After "No"-Answer in Physical Judgment[a]	n_1 for P_3[a]
***M* (*SD*)**	**0%**	**.92 (.05)**	**.99 (.02)**	**--**	**--**
range		.76 - 1.00	.94 - 1.00		
***M* (*SD*)**	**35%**	**.34 (.17)**	**.91 (.09)**	**.86 (.10)**	**32**
range		.00 - .85	.49 - 1.00	.47 - 1.00	
***M* (*SD*)**	**70%**	**.02 (.02)**	**.20 (.15)**	**.18 (.15)**	**49**
range		.00 - .07	.00 - .54	.00 - .54	
***M* (*SD*)**	**new face**	**.01 (.01)**	**.04 (.06)**	**.03 (.06)**	**49**
range		.00 - .06	.00 - .42	.00 - .40	

Note [a] n_1 includes all participants that responded "no" in the physical judgment (irrespective of subsequent response in the identity judgment) and P_3 represents the proportion of these participants that subsequently responded "yes" in the identity judgment.

The "m" and the "w" in the names of the morph-pairs indicate the gender of the face stimuli ("m" = male; "w" = female).

Table 3.

Results of Experiment 2 with $n = 55$ after the exclusion of 20 of the initial 100 morph-pairs.

Morph-Pair	Morph-Degree	P_1: P("Yes") in Physical Judgment	P_2: P("Yes") in Identity Judgment	P_3: P("Yes") in Identity Judgment After "No"-Answer in Physical Judgment[a]	n_1 for P_3
***M* (*SD*)**	**0%**	**.92 (.05)**	**.99 (.02)**	**--**	**--**
range		.76 – 1.00	.94 – 1.00		
***M* (*SD*)**	**35%**	**.31 (.14)**	**.91 (.07)**	**.88 (.08)**	**34**
range		.00 – .61	.72 – 1.00	.69 – 1.00	
***M* (*SD*)**	**70%**	**.01 (.02)**	**.17 (.13)**	**.16 (.12)**	**49**
range		.00 – .06	.00 - .47	.00 – 0.47	
***M* (*SD*)**	**new face**	**.01 (.02)**	**.04 (.04)**	**.03 (.04)**	**49**
range		.00 – .06	.00 – .21	.00 – .21	

Note Ten male morph-pairs (m04, m05, m07, m08, m15, m32, m33, m39, m41, & m48) and 10 female morph-pairs (w02, w10, w17, w32, w34, w37, w38, w43, w47, & w48) were excluded from the initial 100 morph-pairs resulting in a database of 80 morph-pairs.