Inversion effects in recognizing caucasian and Japanese faces

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白人および日本人の顔認知における倒立効果について

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要約

自国人と外国人の顔の認知における倒立効果の大きさに関する2つの仮説を検証する実験を行った。イスラエル人の被験者に対して、実験にはイスラエル人と日本人の正立像と倒立像の顔写真を使用した。実験計画は2（対提示・多肢選択）×3（0遅延時間・1秒遅延・3秒遅延）とした。反応時間と正答率の結果を分散分析した結果、白人の顔は日本人の顔よりも正確に認知され、正立顔は倒立顔よりも正確に認知されたことが明らかとなった。 人種と顔の方向の間の相互作用は正答率の結果でのみ有意となった。正立像と倒立像ともに白人の顔が正確に認知されたが、 有意な差となったのは白人の顔についてだけであった。これらの結果は、他の人種についてよりも自分と同じ人種の顔でより強い倒立効果が見られることを示唆する接触頻度仮説を部分的にではあるが支持している。

Key words

face recognition, inversion effects, contact hypothesis, multidimensional space, Caucasians, Japanese

1. Introduction

Numerous laboratory and field studies have shown that Black and White people recognize own-race faces faster, more accurately, and with more confidence than other-race faces (e.g., Anthony, Copper, & Mullen, 1992; Brigham & Wiliamson, 1979; Bothwell, Brigham & Malpass, 1989; Chance, Goldstein & McBride, 1975; Cross, Cross & Daly, 1971; Ellis & Deregowski, 1981; Lindsay, Jack, & Christian, 1991). Similar "race biases" have been found for a variety of other races. As early as 1914 Feingold demonstrated race biases among Whites and Orientals. Decades later Luce (1974a, b) found that Whites were able to accurately recognize both White and Oriental (Japanese and Chinese) faces, but Orientals recognized only their own-race faces. By contrast, Chance, Goldstein and McBride (1975) reported that both Blacks and Whites found the Japanese faces most difficult to recognize. More recently, Valentine and Endo (1992) reported that both, British and Japanese participants showed race biases in recognizing British and Japanese faces. Counting both correct and incorrect responses, Ng and Lindsay (1994) found that Orientals (mostly Chinese) recognized more accurately Oriental than White faces, but made about equal number of errors in recognizing faces of members of the two races. By contrast, Whites did not show the race bias for correct recognition, but made more errors in recognizing Oriental than White faces. Own-race biases were also found among Europeans in recognition of European and Chinese caricatures of faces (Byatt & Rhodes, 1998). Finally, Ferguson, Rhodes and Lee (2001) found that Caucasian participants recognized their own-race faces better than Chinese faces, whereas Chinese participants recognized faces of both races about equally well.

A number of hypotheses have been put forward to account for the race bias in terms of (1) differential variance in facial features that makes faces of one race easier to recognize than those of another race, (2) prejudice that inhibits processing of faces belonging to disliked races, (3) difficulties in encoding other-race faces in terms of personal attributes, (4) limited contact with other-race faces which impairs their recognition, and (5) multidimensional space where other-race faces are more densely clustered, or more similarly directed, than own-race faces, and are consequently more difficult to discriminate from each other (cf. Ng & Lindsay, 1994; Valentine & Endo, 1992). (For a review of these and other hypotheses, see Wells and Olson, 2001). The first three hypotheses have failed to gain experimental support (Brigham & Barkowitz, 1978; Devine & Malpass, 1985; Goldstein, 1979a, b; Lavrakas, Buri, & Mayzner, 1976), but the last two have been experimentally corroborated.

The contact hypothesis maintains that accuracy of face recognition is a function of the extent of interpersonal contact. Since one has more contacts with same-race than with different-race people, one recognizes better the former than the latter faces (Goldstein & Chance, 1985; Lavrakas et al., 1976). Pertinent experimental data are conflicting (presumably due, in part, to methodological differences). Chiroro & Valentine (1995) found that participants with extensive contacts with other-race people recognized faces of people of that race better than those with whom they had weak contacts. Cross, Cross and Daly (1971) found that White children living in all-white neighborhoods showed more race bias that children living in mixed, white-black neighborhoods (Black children did not show the opposite bias). Similarly, Brigham and his colleagues (Brigham, Maas, Snyder, & Spaulding, 1982) reported a positive correlation between self-reported level of contact with other-race people and the degree of accuracy of face recognition. However, others (Brigaham & Barkowitz,1978; Luce, 1974a, b; Malpass & Kravitz, 1969) have failed to find similar correlations. Ng and Lindsay (1994) also found no relationship between extent of interracial contacts and degree of accuracy of face recognition.

Another technique used to test the contact hypothesis employs the "inversion effect" in face recognition. This effect refers to the unusual difficulty (as compared with other objects) in recognizing inverted than upright faces (Leder & Bruce, 2000; Valentine, 1988; Yin, 1969). According to the contact hypothesis, the degree of difficulty in recognizing inverted faces is associated with the extent of interpersonal contact: The more a given face looks familiar when presented in the upright orientation, the more difficult will its recognition be when presented in the inverted orientation. However, that prediction was not borne out (Scapinello & Yarmey, 1970; Yarmey, 1971). Assuming that familiarity with own-race faces is greater than with other-race faces, and that configural processing of upright faces is more prominent in the recognition of own-race than of other-race faces, it was further predicted that the inversion effect would be greater for the former than for the latter. This prediction was corroborated by Rhodes, Tan, Brake and Taylor (1989), but opposite results were reported by Valentine and Bruce (1986).

An alternative hypothesis for the race bias effect was offered by Valentine (1991) who argued that perceived faces are encoded as points in a multidimensional space. Since those dimensions are created on the basis of familiarity with own-race faces, they are more efficient in encoding own-race than other-race faces (Valentine, 1991; Valentine, Chiroro, & Dixon, 1995). Indeed, it has been found (Ellis, Deregowski, & Shepherd, 1975; Shepherd and Deregowski, 1981) that black and white faces are described by references to different facial features (blacks by nose and tone of skin color, and whites by hair color). However, regardless of race, people prefer to use for face recognition the more familiar dimensions, thus adversely affecting accuracy of other-race face recognition. Assuming that both upright own-race and other-race faces are processed figuratively, then according to the multidimensional space model, the inversion effect will be more pronounced in the recognition of other-race than own-race faces, since the former faces are less distinguishable from each other, and are therefore more likely than own-race faces to be inaccurately recognized. This prediction was borne out (Valentine & Bruce, 1986).

Concerning the inversion effect, it appears that the contact and the multidimensional space hypotheses predict opposite racial biases: The former predicts a greater effect for the recognition of own-race than other-race faces, whereas the latter predicts the opposite finding. In the present study these differential predictions were tested by presenting Israeli participants with a series of own-race (Caucasian) and other-race (Japanese) faces for recognition under both, upright and inverted orientations. Testing was conducted under two test (paired matching [PM] and multiple choice [MC]) and three delay (0, 1 and 5 s.) conditions.

2. General method

2.1 Stimuli

Thirty two frontal, black and white photographs of faces; 16 Caucasian and 16 Japanese (in each category, half males and half females) were used as stimuli. The faces which were 4 cm wide and 6.5 cm long (see Figure 1), were prepared for presentation in two orientations, upright and inverted. For each orientation, four categories of faces of eight stimuli each were prepared: Japanese females, Japanese males, Caucasian females and Caucasian males. In order to make the recognition tasks relatively difficult, care was taken to insure maximum similarity (in terms of overall configuration and hairstyle) among all faces in a stimulus set.

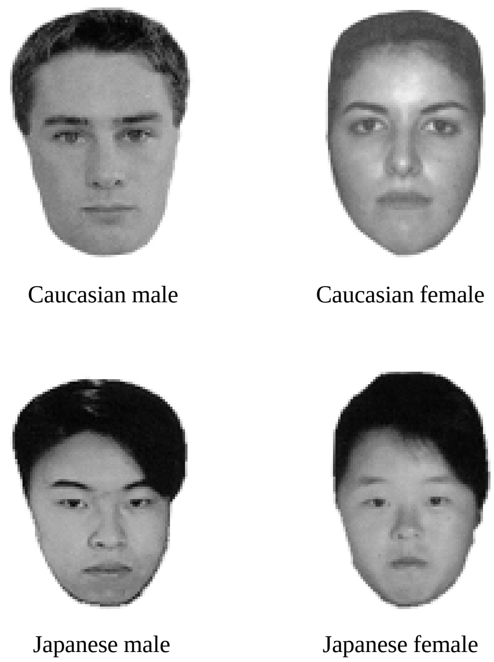

Figure 1: A sample of Caucasian and Japanese faces

2.2 Procedure

The facial stimuli were presented on a Power Macintosh G3 by Face Research Software on a 20" monitor. The participants were tested individually. For each participant, mean response accuracy and reaction time (RT) were calculated for analysis. For each task, the first four trials were used for practice, and their data were not analyzed. Order of presentation of the four stimulus categories (Caucasian males and females, Japanese males and females) was systematically randomized by a Latin Square design. Each order was presented to eight participants (in Experiments 1 and 2, half males and half females). For each order, four participants (in Experiments 1 and 2, half males and half females) were first presented with the upright faces, while the other four were first presented with the inverted faces. One member of each pair of participants was presented with the stimuli in a given order, while the other was presented with them in the opposite order. Intertrial interval was 1.5 s..

3. Experiments 1 and 2: Pair matching

3.1 Experiment 1: Simultaneous presentation

3.1.1 Participants

Sixteen Israeli undergraduate students (half males and half females) were tested.

3.1.2 Stimuli

For each category of four faces, the stimuli were prepared in vertical pairs with one member of each pair located 2.5 cm above the other. Each stimulus was paired with the other three stimuli as well as with itself. Each pair of facial stimuli was duplicated with the stimulus orientations reversed. Consequently, each face appeared four times above the other member of a pair, and four times below it. The total number of stimulus pairs was therefore 128.

An identical collection of stimuli was prepared with the faces inverted.

Two keys on the keyboard, marked Y (for matches) and N (for mismatches), were designated for participants' responses.

3.1.3 Procedure

For each trial the participants pushed, as fast as possible, the Y key when the two faces in a pair matched, and the N key when they did not match.

3.2 Experiment 2: Sequential presentation

3.2.1 Participants

Thirty two Israeli undergraduate students (half males and half females) were tested.

3.2.2 Procedure

The procedure was the same as the one used in Experiment 1, except that the two faces in a pair were presented sequentially, so that for each pair, a given face appeared for 1 s., followed by the scond face after 1 s. delay (for half the participants) and 5 s. delay (for the scond half).

4. Experiments 3 and 4: Multiple choice

4.1 Experiment 3: Simultaneous presentation

4.1.1 Participants

Sixteen female undergraduate students were tested.

4.1.2 Stimuli

For each group, the stimuli were arranged in horizontal sets, each consisting of a centrally located target face, and four horizontally displayed test faces (4.8 cm apart) located 4.5 cm below the target face. The test faces were numbered 1-4 from left to right. The target face was always identical to one of the test faces. Each stimulus face was used four times as a target face, and 12 times as a test face; four times in each of the four horizontal locations.

4.1.3 Procedure

On any given trial the participants pushed, as fast as possible, the key whose number (1-4) corresponded to the number of the test face which matched the target face.

4.2 Experiment 4: Sequential presentation

4.2.1 Participants

Thirty two female undergraduate students were tested.

4.2.2 Procedure

The procedure was the same as the one used in Experiment 3, except that the target and test faces were presented sequentially, so that for each stimulus set, the target face appeared for 1 s., followed by the test faces after 1 s. delay (for half the participants) and 5 s. delay (for the scond half).

5. Results

The data of all four experiments were analyzed together by a 2 (Race) x 2 (Orientation) x 2 (Test) x 3 (Delay) MANOVA with repeated measurements. Since preliminary t-test analyses showed no significant effect of sequence of presentation or sex differences, the data were pooled together across these variables for analysis.

5.1 Reaction time

Mean RT for correct matches, made by each participant under each experimental condition, were calculated for analysis. For each participant, RTs of over or under two standard deviations were excluded from analysis. The data are presented in Table 1 which shows that overall, all four main effects (Race, Orien-

Table 1: Mean reaction times in recognition of Caucasian and Japanese faces

Task	Race	Orientation			
		Upright		Inverted	
		Mean	SD	Mean	SD
Pair Matching					
0 s. delay	Caucasian	1192.39	416.44	1480.36	522.51
	Japanese	1280.95	309.93	1475.69	439.25
1 s. delay	Caucasian	694.70	133.93	782.06	147.40
	Japanese	731.82	129.87	782.90	89.15
5 s. delay	Caucasian	955.10	240.66	1056.79	233.74
	Japanese	1007.91	286.91	1118.28	165.99
Multiple Choice					
0 s. delay	Caucasian	1964.12	435.53	2531.23	878.35
	Japanese	2195.88	462.94	2657.45	650.15
1 s. delay	Caucasian	1323.31	338.79	1449.64	313.87
	Japanese	1444.86	312.30	1565.74	321.06
5 s. delay	Caucasian	2048.23	586.16	2448.93	633.77
	Japanese	2472.45	781.32	2771.21	922.37

tation, Delay and Test) were significant. Caucasian faces (mean: 1493.90 ms.; SD: 703.16) were significantly ($F_{1,90}$ = 28.15; p < .001) faster recognized than Japanese faces (mean: 1625.43 ms.; SD: 810.47); upright faces (mean: 1442.64 ms., SD: 674.43) were significantly ($F_{1,90}$ = 51.16; p <.001) faster recognized than inverted faces (mean: 1676.69 ms.; SD: 849.88); recognition of faces presented with 1 s. delay was fastest (mean: 1096.88 ms.; SD: 412.78), that of faces presented with 5 s. delay was slower (mean: 1734.86 ms.; SD: 865.98), and face recognition under simultaneous presentation was slowest (mean: 1847.26 ms.; SD: 672.01). Overall, these differences were significant ($F_{2,90}$ = 30.91; p <.001). However, as Schefe's test indicated, the only significant (p < .05) difference was between 1 s. delay and the other two delay conditions. Finally, PM (mean: 1046.58 ms.; SD: 338.24) was significantly ($F_{1,90}$ = 149.09; p <.001) faster than MC (mean: 2072.75 ms.; SD: 689.77).

Orientation significantly interacted with Delay ($F_{2,90}$ = 6.17; p <.003) and with Test ($F_{1,90}$ = 8.46; p <.005). As a series of t-tests showed, for each of the three delays (0, 1, 5 s.) and two experimental conditions (PM, MC), upright faces were significantly (p <.006) faster recognized than inverted faces.

Race significantly interacted with Delay ($F_{2,90}$ = 3.08; p <.05) and with Test ($F_{1,90}$ =13.82; p <.001). As a series of t-tests showed, under all delay conditions (0, 1, 5 s.), Caucasian faces were faster recognized (p <.01) than Japanese faces. These differences were significant (t_{47} = 5.14; p <.001) for MC, but not for PM. Test significantly ($F_{2,90}$ = 5.90; p <.005) interacted with Delay. Under both experimental conditions, recognition of faces under 1 s. delay was significantly (p < .01) fastest (for PM and MC, mean [and SD] scores were: 747.87 [90.29] and 1445.89 [290.04], respectively); for PM, recognition under 5 s. delay (mean: 1034.52; SD: 194.21) was significantly (p < .01) shorter than under no delay (mean: 1357.35; SD: 338.03); for MC, no significant difference appeared for face recognition under these two conditions (for 5 and 0 s. delay, mean [and SD] scores were: 2435.21 [682.48] and 2337.17 [554.09], respectively. No other interactions were significant.

5.2 Accuracy

For each task, mean correct responses were calculated for each participant, and used for analysis. The data are presented in Table 2 which shows that two of the four main effects (Race and Orientation) were significant. Caucasian faces (mean: 83.85; SD: 6.88) were significantly ($F_{1,90}$ = 6.90; p <.01) more accurately recognized than Japanese faces (mean: 82.13; SD: 9.22); upright faces (mean: 86.70; SD: 6.81) were significantly ($F_{1,90}$ = 98.96; p < .001) more accurately recognized than inverted faces (mean: 79.28; SD: 9.93).

Orientation significantly interacted with Race ($F_{1,90}$ = 4.34; p <.04), with Delay ($F_{2,90}$ = 3.27; p <.04) and with Test ($F_{1,90}$ = 6.25; p < .01). For each orientation (upright, inverted), Caucasian faces were more accurately recognized than Japanese faces. However,

Table 2: Mean accurate recognition of Caucasian and Japanese faces

Task	Race	Orientation			
		Upright		Inverted	
		Mean	SD	Mean	SD
Pair Matching					
0 s. delay	Caucasian	88.18	4.03	73.73	9.73
	Japanese	85.25	8.10	68.16	13.77
1 s. delay	Caucasian	90.82	5.67	81.44	9.39
	Japanese	87.20	9.61	81.25	14.91
5 s. delay	Caucasian	87.01	6.47	80.46	7.14
	Japanese	83.10	7.17	80.85	7.13
Multiple Choice					
0 s. delay	Caucasian	90.52	5.91	85.54	7.36
	Japanese	90.33	5.26	86.62	9.35
1 s. delay	Caucasian	85.74	6.50	77.53	9.32
	Japanese	81.93	11.62	79.29	9.72
5 s. delay	Caucasian	86.42	7.36	78.80	11.62
	Japanese	83.88	9.72	77.73	8.45

this difference was significant (t_{95} = p < .001) for the upright faces only. As a series of significant (p < .001) t-tests further showed, for each race, test and delay, upright faces were more accurately recognized than inverted faces. However, for both upright and inverted orientations no significant differences appeared for the three delay conditions.

A significant ($F_{2,90}$ = 8.14; p <.001) Test x Delay interaction showed that for PM face recognition was most accurate under 1 s. delay, and least accurate under simultaneous presentation; for MC, face recognition was more accurate under simultaneous presentation than under 1 s. and 5 s. delays.

A three-way interaction of Orientation with Delay and Test was significant ($F_{2,90}$ = 7.51; p <.001), but no meaningful pattern of results appeared. All other interactions were not significant.

Accuracy-RT trade-offs were measured by a series of correlations for the various experimental conditions. None of them was significant.

Discussion

The most robust, albeit not new finding of the present study was the inversion effect: Across all experimental conditions (Test, Delay and Race) upright faces were better (faster and more accurately) recognized than inverted faces. This finding is consistent with the data of earlier studies where face recognition involved memory processes (Diamond and Carey, 1986; Sergent, 1984; Farah, Tanaka, & Drain, 1995; Valentine & Bruce, 1986; Valentine, 1991). The results of the present study show that although the effect is usually most conspicuous when an element of memory (1 s. delay) is involved, it also appears under simultaneous presentation where perceptual rather than memory processes are involved. Interestingly, under 5 s. delay the effect seems to attenuate to the level that is evident under simultaneous presentation. It may be speculated that the magnitude of the inversion effect depends on the level of task difficulty: It is maximal when the level of difficulty is optimal; neither too easy (no delay), nor too difficult (5 s. delay). In light of similar patterns of performance previously reported for other tasks (Nachshon, 1973), this speculation sounds reasonable, yet it needs experimental corroboration.

Turning now to the main issue of the present study, the most important question is whether accuracy differences between the upright and inverted presentations are greater for the recognition of own-race (Caucasian) than for other-race (Japanese) faces. As further inspection of the data shows, while the upright-inverted accuracy differences were significant for both race categories, they were significantly ($t_{95} = 2.07$; $p < .04$) greater for the Caucasian (mean: 8.52) than for the Japanese (mean: 6.30) faces. Similarly, RT differences were greater for the former (mean: 261.86 ms.) than for the latter (mean: 206.24 ms.); however, this difference was not significant. Together, these findings seem to lend partial support to the contact hypothesis (Goldstein & Chance, 1985; Lavrakas et al., 1976) which predicted greater inversion effect for the recognition of own-race than of other-race faces. That means that the race bias (which is evident in the present study by faster and more accurate recognition of Caucasian than of Japanese faces) is presumably due mainly to the greater familiarity with faces of one's own race than with those of other races. However, the fact that the more accurate recognition of the Caucasian faces was significant in the upright orientation only might indicate that facial features that normally distinguish between own-race and other-race faces lose their usefulness under inversion; presumably because the familiar relationships among these features are altered in inversion (Ellis, 1975; Endo, 1986; Leder & Bruce, 2000; Murray, Yong, & Rhodes, 2000; Rock, 1974; Sergent, 1984; Tanaka & Farah, 1991; but see Valentine, 1988).

Comparison of the results of the present study with those of previous studies is difficult due to data inconsistency among those studies. Orientation x Race interaction has been examined in three studies. Valentine and Bruce (1986) found that when black and white faces were inverted, White participants showed a larger inversion effect (in terms of both RT and accuracy) for black than for white faces. Buckhout and Regan (1988) found that both White and Black participants showed inversion effects as well as race biases, but the former was similar for the recognition of own-race and other-race faces. Finally, testing European and Chinese participants, Rhodes et al. (1989) found larger inversion effects, in terms of both RT (Experiment 1) and accuracy (Experiment 2), for the recognition of own-race than other-race faces (cf. Valentine, 1991, for methodological comments on these experiments). Clearly, the inconsistency in findings of the three studies makes it impossible to derive a meaningful conclusion from them. While the reason for the inconsistency cannot be determined, it makes sense to postulate that the differences in the participants' ethnic origins, the facial stimuli used and the amount of interracial contacts, have contributed to data variability. Further research is needed to delineate the main and interactive effects of these variables.

Finally, consistent with previous research (Kagan, 1965; Rotenberg & Nachshon, 1979; but see Nachson & Shechory, 2002) accuracy-RT trade-off appeared: Increments in accuracy were accompanied by corresponding increments in RT. This correspondence was most conspicuous in the PM-MC comparison: Face recognition under PM was faster but less accurate than under MC. These data clearly show that it takes longer to match a target face with four test faces than with a single face. However, it seems that this laborious process has its benefits as it enhances matching accuracy.

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