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Ignoring famous faces: Category-specific dilution of distractor interference

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The extent to which famous distractor faces can be ignored was assessed in six experiments. Subjects categorized famous printed target names as those of pop stars or politicians, while attempting to ignore a flanking famous face distractor that could be congruent (e.g., a politician's name and face) or incongruent (e.g., a politician's name with a pop star's face). Congruency effects on reaction times indicated distractor intrusion. An additional, response-neutral flanker (neither pop star nor politician) could also be present. Congruency effects from the critical distractor face were reduced (*diluted*) by the presence of an intact anonymous face, but not by phase-shifted versions, inverted faces, or meaningful nonface objects. By contrast, congruency effects from other types of distracting objects (musical instruments, fruits), when printed names for these classes were categorized, were diluted equivalently by intact faces, phase-shifted faces, or meaningful nonface objects. Our results suggest that distractor faces act differently from other types of distractors, suffering from only face-specific capacity limits.

Although the brain is fed a constant stream of information from the senses, only a fraction of this enters awareness. Selection of information for further processing is contingent upon at least two factors: its top-down relevance in terms of current task priorities and its bottom-up ability to capture attention regardless of such priorities. Thus, some irrelevant but salient stimuli may undergo considerable visual processing despite observers' attempts to ignore them, provided they are sufficiently capable of capturing attention (see, e.g., Yantis & Jonides, 1990). To date, many studies of selective attention have focused on the processing of fairly neutral stimuli, such as letters or abstract shapes. Stimuli of intrinsic biological salience, such as faces, have seldom been presented as distractors. In the present study, we examined situations in which faces appeared as task-irrelevant distractors, testing whether their processing was subject to principles and capacity limits similar to those of other classes of distractors or, instead, would produce effects suggesting face-specific capacity limits. Since much of the information faces carry is of adaptive importance (e.g., person identity, emotion), it seemed possible that distractor faces might be processed even under conditions that are optimal for rejection of other classes of distractors. We will begin with a short review of some principles of selective attention already known to mediate distractor processing for the much-studied case of irrelevant letters or words. We then will consider the possible implications of such studies for the ability to ignore salient biological stimuli, such as faces (i.e., to exclude them from affecting task performance, when presented as distractors).

Elucidating the optimal conditions for efficient distractor rejection has been a central goal of selective attention research since the 1950s (see Broadbent, 1958). To this end, many studies have presented letters or words as irrelevant distractors, assessing their processing indirectly via effects of such distractors on reaction times (RTs) to target stimuli. For example, numerous studies have measured Stroop-like interference from irrelevant words (e.g., Hagenaar & van der Heijden, 1986; Kahneman & Henik, 1981; Stroop, 1935), or *response competition* effects from irrelevant flanking letters (e.g., B. A. Eriksen & C. W. Eriksen, 1974; Miller, 1987). In many such studies, subjects were apparently unable to completely prevent distractor processing from affecting task performance, since target RTs were slowed by incongruent distractors, relative to congruent distractors. Such interference effects are typically reduced when the segregation of target and distractors is increased—for example, by increasing spatial separation between targets and distractors (e.g., C. W. Eriksen & Hoffman, 1972) or by placing them in different perceptual groups (Baylis & Driver, 1992; Kramer & Jacobson, 1991). However, some distractor effects have been reported even from dis-

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tractors that were clearly segregated and spatially separated from the target (e.g., Gatti & Egeth, 1978). It is possible that an isolated distractor may always interfere to some extent, even when distant from the target (see the review in Lavie & Tsal, 1994), perhaps owing to the ability of a salient isolated stimulus in the periphery to capture attention (e.g., Yantis & Jonides, 1990). However, such distractor effects can be eliminated in more *cluttered* displays, such as those with several distractors. C. W. Eriksen and Hoffman (1972) and Yantis and Johnston (1990) showed that distractor congruency effects can be abolished for distractors that are distant from the target in such cluttered displays. Indeed, interference from one critical distractor can be decreased merely by adding another distractor to the display. For example, Kahneman and Chajczyk (1983) demonstrated, in a color-naming task, that Stroop-like interference from a distractor color-word in the periphery can be *diluted* simply by adding one response-neutral stimulus (e.g., a row of Xs) to the display.

The role of such clutter (i.e., additional items) in constraining distractor processing has recently been emphasized in the *perceptual load* account of selective attention developed by Lavie (e.g., Lavie, 1995, 2001; Lavie & Tsal, 1994), which accounts for distractor processing in terms of the perceptual load in the processing situation. In situations of high perceptual load, induced by increasing the number of stimuli that clutter the display (or by increasing the perceptual demands of the display), intrusion from distractors is naturally prevented, owing to attentional capacity's being fully consumed by the relevant processing. However, in situations of low perceptual load (e.g., when just one target and one distractor are presented), any spare capacity not consumed by relevant processing will inevitably *spill over* to irrelevant distractor processing. These claims have been supported by a number of recent studies demonstrating that distractor influences (as measured by congruency effects or negative priming) are always found in conditions of low perceptual load in relevant processing, being eliminated only by high perceptual load (e.g., Lavie 1995; Lavie & Cox, 1997; Lavie & Fox, 2000).

To date, however, as with much previous attention research, this load theory has been concerned primarily with fairly arbitrary distractor stimuli of little biological significance (e.g., letters). Such research cannot determine whether more biologically significant distractors, such as faces, can ever be ignored sufficiently to have no impact on task performance. Because of their special significance, stimuli such as faces might continue to elicit distractor effects not only when clearly segregated from the target, but even when accompanied by other cluttering stimuli in a high-load display. This was tested in the present study, in which we compared the influence of different types of clutter (i.e., different types of additional distractor stimuli).

The idea that faces may be *special* and processed in a mandatory way has previously been forwarded on the basis of several lines of research, none directly concerned with distractor processing. These include developmental studies (e.g., Goren, Sarty, & Wu, 1975; Maurer & Salapatek, 1976; Morton & Johnson, 1991), functional imaging and single-cell studies (e.g., Kanwisher, McDermott, & Chun, 1997; Perrett, Hietanan, Oram, & Benson, 1992; Puce, Allison, Gore, & McCarthy, 1995), and neuropsychological studies of patients with prosopagnosia (Farah, Levinson, & Klein, 1995; Farah, Wilson, Maxwell Drain, & Tanaka, 1995; McNeil & Warrington, 1993). This research has led to claims that face processing may be subserved by dedicated neural systems (but see Gauthier, Behrmann, & Tarr, 1999). Indeed, some researchers (e.g., Farah, Wilson, et al., 1995; Kanwisher et al., 1997) have explicitly proposed that face processing may be conducted by a specialized module, operating in a mandatory fashion in the presence of face input. Such automaticity (in the sense of mandatory, capacity-free processing) has often been proposed as characteristic of specialized modules (see Fodor, 1983), and there have been many proposals that face processing is automatic in this specific sense (e.g., Farah, Wilson, et al., 1995). If so, distractor faces should still be processed when task irrelevant, regardless of the level of clutter or perceptual load in the display.

Despite the weight of evidence from neuropsychology and neuroscience for specialized face processing, there is as yet little direct psychological evidence for claims concerning its automaticity. One approach to this issue has involved visual search tasks. Several studies have failed to demonstrate unequivocally parallel search for faces among nonfaces (Brown, Huey, & Findlay, 1997; Koehn & Jolicœur, 1994; Nothdurft, 1993), although some of these cases may have involved acuity limits when large set sizes that enforced small individual items were used. More recently, Tong and Nakayama (1999) reported faster visual search for one's own face. Suzuki and Cavanagh (1995) found that a cost in feature search (e.g., for a curved-up mouth-like feature) is incurred if both target and nontarget features are embedded in schematic face configurations. This implies that configural processing of faces may be mandatory, at least when elements of the faces are task relevant (as when a particular feature is searched for among them), rather than the faces being entirely task irrelevant.

In standard visual search tasks, all stimulus locations and all items are, in fact, potentially task relevant, since the target can typically appear anywhere and all items may require discrimination. Hence, the *nontarget* items may, in fact, be attended as task relevant in many search tasks (whether serially or in parallel). Young, Ellis, Flude, McWeeny, and Hay (1986) more directly addressed the possible automaticity of processing for *task-irrelevant* face distractors, using a very different method. They requested observers to categorize printed famous names as those of pop stars or politicians, while trying to ignore a distractor face (presented nearby, at a resolvable eccentricity). Target RTs were longer in trials containing an incongruent distractor face (e.g., a pop star's face presented with a politician's name) than in trials containing a congruent face (i.e., when the face and the name matched). These results suggest that subjects were unable to prevent semantic categorization of the distractor face (in terms of occupation) under the experimental conditions. Note also that according to standard models of face processing (e.g., Bruce & Young, 1986), extraction of semantic information about a face (such as the occupational category of its owner) is thought only to follow identification of that face. Hence, these results have also been taken to indicate automatic identification of distractor faces.

However, the concurrent target and the distractor were always grouped together in Young et al.'s (1986) study (the name was presented in a *speech bubble* extending from the face's mouth), and such grouping is known to impede distractor rejection (e.g., Baylis & Driver, 1992; Kramer & Jacobson, 1991). Moreover, it is not clear from Young et al.'s pioneering study whether distractor faces are *particularly* hard to ignore, as compared with other stimulus classes. Similar picture–name interference effects can be obtained with nonface stimuli (Smith & Magee, 1980). Indeed, even within Young et al.'s study, similar congruency effects were found from printed names when these served as distractors and the faces as targets.

In order to examine whether face distractors may act differently from other types of distractors (e.g., nonface objects) when task irrelevant, we used a variation of Young et al.'s (1986) task, with several modifications designed to provide optimal conditions for distractor rejection. Subjects were asked to classify a central printed target name as that of a pop star or a politician, while ignoring an irrelevant famous face distractor that could be congruent or incongruent with the target name. The target name was always presented at fixation, whereas the distractor face was presented in the periphery, clearly separated from the target name. We examined whether presenting other response-neutral stimuli together with the distractor face, to *clutter* the array in various ways, could dilute congruency effects from the famous face distractor. To anticipate, we found that only adding another intact distractor face to the display could do this. By contrast, congruency effects from nonface distractors could be diluted by any of the additional stimulus types used.

EXPERIMENT 1

In Experiment 1, subjects were requested to make a speeded categorization response, concerning whether a printed name at fixation was that a politician or a pop star, while ignoring an irrelevant politician's or pop star's face presented to the right or left of the name. This famous face distractor could be either congruent or incongruent with the central name, and congruency effects on target RTs were measured under three conditions. The famous face distractor was presented (1) alone (in the *blank* condition), (2) with an intact anonymous face on the opposite side of the target (*intact* face condition), or (3) with a phase-shifted version of an anonymous face, which was no longer recognizable as a face, on that side (*phase-shifted* condition; see Figure 1). The phase-shifted anonymous face was intended to serve as a control only for the low-level visual energies of the intact anonymous face (since it matched these exactly for each of the component spatial frequencies, yet did not resemble a face or any other meaningful object). As was stated in the introduction, if face processing is automatic not only in the sense that it cannot be voluntarily withheld, but also in that it is capacity free, we should find congruency effects from the famous distractor faces regardless of the nature and number of any other stimuli in the display. On the

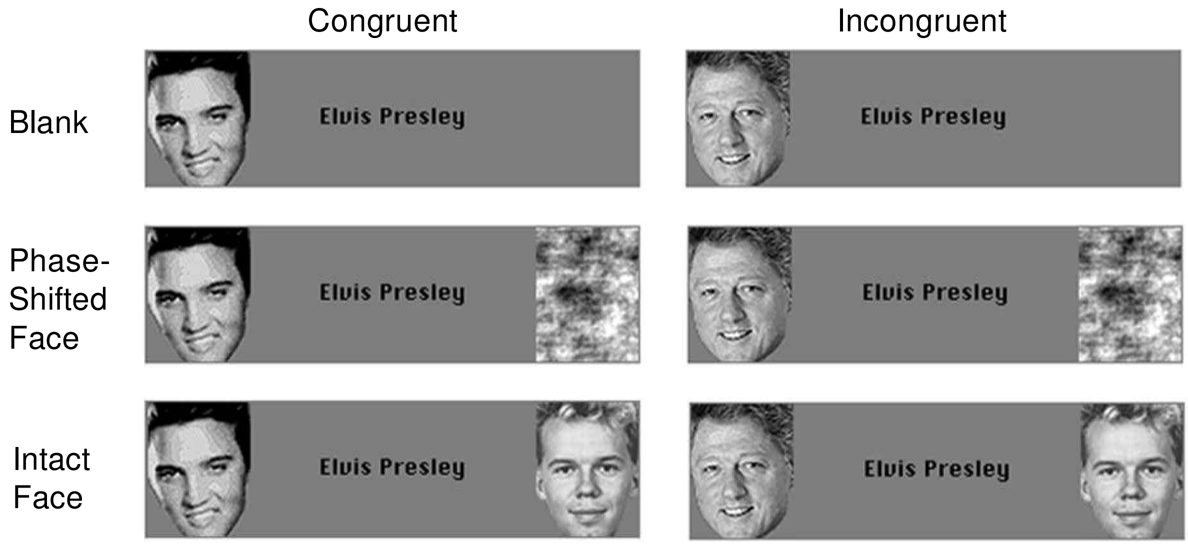

Figure 1. Example displays from the six conditions in Experiment 1.

other hand, if faces are processed no differently from other distractor stimuli, we should find larger congruency effects from this distractor face when it is the sole distractor. These effects should be diluted once any other stimulus is added to the display, as in Kahneman and Chajczyk (1983). Finally if any capacity limits are specific to the processing of intact faces, only an additional intact face should dilute interference from the famous face distractor; the phase-shifted stimulus should have no impact.

Method

Subjects. Twenty-six students from University College London, whose ages ranged from 18 to 28 years, were paid £3 to participate. All had normal or corrected vision by self-report. A test at the beginning showed that they recognized the famous faces they were to encounter in the experiment.

Apparatus and Stimuli. An Apple Macintosh computer attached to a color monitor presented the stimuli and recorded the responses, using Superlab 1.68. Viewing distance was fixed at 60 cm by a chinrest. The names and faces of six male pop stars (David Bowie, Mick Jagger, Elton John, John Lennon, Jim Morrison, and Elvis Presley) and six male politicians (Tony Blair, George Bush, Bill Clinton, William Hague, John Major, and Ronald Reagan) were used for targets and critical distractors. A further set of 12 anonymous faces was used in conditions containing additional flankers. These anonymous flankers should be response neutral, since they were not associated with any of the names, occupations, or responses that were of relevance to the task of classifying the famous printed names. A phase-shifted version of each of the anonymous faces was also made by randomly shifting the phase of the component spatial frequencies of each intact anonymous face, after Fourier analysis (see McCarthy, Puce, Gore, & Allison, 1997). Note that this procedure preserves the amplitude of the component spatial frequencies across the spectrum, in comparison with the original intact face. It thus served to control for such low-level visual energies, as well as for overall brightness and size.

All faces were grayscale images derived from photographs and measured 2.1 cm × 2.8 cm (subtending 2.0° × 2.7° of visual angle at the viewing distance of 60 cm and, thus, clearly resolvable when centered at 4.0° of eccentricity in the experimental displays), after being cropped to remove extraneous background. Cropping resulted in some loss of the face outline (see Figure 1) but was implemented to prevent spatial frequencies in the surrounding background from contaminating the phase-shifted stimuli. Each display contained 1 name (shown in black 12-point Arial font) centered at fixation and measuring between 2.3 cm (the shortest name) and 3.4 cm (the longest name) in width (2.2°–3.2° of visual angle). A famous face distractor was presented either to the left or to the right of the central name. The nearest contours of the target word and the critical distractor face were separated by 1.2 cm (1.1° of visual angle). The concurrent name and the famous face in each display were equally likely to be congruent (a face that matched the target name; e.g., David Bowie's face with David Bowie's name) or incongruent (a face that matched a name from the opposite category; e.g., David Bowie's face with Bill Clinton's name). For the incongruent condition, all six faces from the other category were equally likely to be paired with each target name. The space on the opposite side of the famous distractor face was equally likely to be blank, to contain an intact anonymous face, or to contain a phase-shifted version of an anonymous face. Combining each of the 12 target names with a congruent or an incongruent famous distractor face, under three levels of the flanker type on the other side, resulted in a total of 72 display variations.

Procedure. Prior to the onset of each display, a black fixation point appeared at the center of the screen for 500 msec. This was replaced by a display consisting of a target word plus flanker(s), which appeared for 200 msec (i.e., too briefly to permit saccades during its exposure) against a light gray background. The subjects made a speeded judgment concerning whether the target name was that of a pop star or a politician. Responses were made with the right hand, using the numeric pad on the right of the standard computer keyboard, pressing the "3" key to indicate a pop star's name or the "." key to indicate a politician's name. Feedback for errors was given immediately by a short tone. If no response was made within 3 sec, feedback was given by the same tone, and the next trial was initiated. The subjects were emphatically instructed to ignore the irrelevant distractors and were warned that failure to ignore them could impair performance. Following a short block of 12 example trials, each subject underwent seven blocks of 72 trials each. All the experimental conditions were randomly intermixed within each block. The example block and the first experimental block were discarded as practice. The subjects were able to rest between blocks, initiating the next block by pressing the space bar.

Results and Discussion

Incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were excluded from RT analysis. Data from 2 subjects—1 whose error rate was 36% and 1 whose response latencies were exceptionally slow (1.9 *SD* from the group mean)—were also excluded. Mean correct RTs and percentage error rates were then computed for each level of congruency (i.e., congruent vs. incongruent) and display type (blank, phase shifted, and intact). The averages of these RTs and error rates across subjects are shown in Table 1.

RTs. A two-way within-subjects analysis of variance (ANOVA) on the mean RT data, with factors of distractor congruency (two levels) and display type (three levels), showed a main effect of congruency [$F(1,23) = 37.97$, $p < .01$], with slower responses to incongruent displays, but no reliable main effect of display type [$F(2,46) = 2.55$, $p = .08$]. More important, the main effect of congruency was modified by an interaction with display type [$F(2,46) = 3.79$, $p < .05$]. As can be seen in Table 1, although congruency effects from the critical famous distractor faces were found in all conditions ($p < .05$ in each case), one-tailed t tests showed that these distractor effects were significantly smaller in the condition with an additional intact face than in the condition with an additional phase-shifted face [$t(1,23) = 1.82$, $p < .05$] or than in the blank condition, in which the distractor appeared alone [$t(1,23) = 2.54$, $p < .01$]. There was no difference in the distractor effects between the blank and the phase-shifted conditions ($t < 1$).

Table 1
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects ($n = 24$) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 1

	Distractor Condition						Effect Size (I − C)	
	I			C				
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Blank	484	19	11	441	17	8	43	3
Phase shifted	491	21	11	459	18	9	32	2
Intact	476	19	10	458	19	9	18	1

Note—I, incongruent; C, congruent.

Errors. Comparable analyses were conducted on the error data. A two-way ANOVA (congruency × display type) found only a main effect of congruency [$F(1,23) = 19.38, p < .01$]. As can be seen in Table 1, incongruent conditions resulted in a 2% increase in the number of errors under all display conditions. There were no other effects in the analysis of error rates (Fs < 1 for all).

These results extend Young et al.'s (1986) finding that an irrelevant face can interfere with the categorization of a target name. We found this even with a clear spatial separation between target and distractor. The more specific aim of this experiment was to determine whether congruency effects from a famous distractor face could be affected by the presence of an additional, response-neutral flanker. Our RT results show that face–name interference can indeed be diluted, by adding an anonymous upright face as a further flanker, in addition to the critical famous face. This is an important finding, since it runs counter to any claims that congruency effects from famous face distractors are automatic in the sense of being entirely capacity free. Finally, our results suggest that face–name interference cannot be diluted merely by any additional stimulus. Although an upright unknown face produced significant dilution, a phase-shifted stimulus did not produce any dilution, despite sharing low-level energies with the effective intact face. Nevertheless, it might be argued that although controlling for such energies, the phase-shifted stimulus did not control for other properties. This was addressed in the next experiment.

EXPERIMENT 2

The dilution produced by adding an intact face in Experiment 1 cannot have been due simply to its low-level visual energies, given the different result for the phase-shifted stimuli. However, the latter do not control for edge or structural information (see Figure 1). In the next experiment, inverted faces were used as the "nonface" control instead. Although inverted faces are identical to upright faces in every respect except orientation (thus preserving many intrinsic stimulus properties), they are poorly perceived and recognized, as compared with their upright equivalents (e.g., Diamond & Carey, 1977; Valentine, 1988; Yin, 1969).

Method

Subjects. Twenty-six new subjects (15 female) from University College London, whose ages ranged from 18 to 30 years, were paid £3 for participating in the experiment. All had normal or corrected vision by self-report and recognized the famous faces they were to encounter in the experiment.

Stimuli and Procedure. The stimuli and procedure were the same as those in Experiment 1, except for the following changes. The set of phase-shifted faces was replaced by a set of inverted faces produced from the intact anonymous faces. The outlines of all the faces (famous, anonymous upright, and anonymous inverted) were now preserved, since the images were no longer cropped, as had been previously required for the phase-shifting process. Consequently, the images were slightly larger than those used in Experiment 1: Height was fixed at 3.5 cm (3.3° of visual angle), and width varied slightly between images (2.6–3.0 cm; 2.5°–2.9° of visual angle). As in Experiment 1, the nearest distractor contours were 1.2 cm (1.1° of visual angle) away from the target, so all the faces were resolvable. After an example block of 12 trials and a practice block of 72 trials, the subjects completed seven experimental blocks of 72 trials.

Results and Discussion

RTs. Incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were excluded from the RT analysis. The mean RTs and error rates across subjects are shown in Table 2 as a function of experimental condition.

A two-way within-subjects ANOVA (display type [3] × congruency [2]) on the RT data showed a main effect of congruency [$F(1,25) = 17.27, p < .01$], with slower responses to incongruent than to congruent trials, as in Experiment 1. As before, there was no main effect of display type ($F < 1$). More important, the main effect of congruency was again qualified by an interaction with display type [$F(2,50) = 3.88, p < .05$]. As can be seen from Table 2, although the critical famous face distractors produced congruency effects when appearing alone [$t(1,25) = 12.38, p < .01$] or accompanied by an anonymous inverted face [$t(1,25) = 16.09, p < .01$], there was no congruency effect when an upright anonymous face was added ($t < 1$). There was no significant difference in congruency effects between trials containing an inverted face and trials containing no additional flanker ($t < 1$). An intact (upright anonymous) face produced significant dilution relative to each of the latter two conditions [$t(1,25) = 2.02, p < .05$, and $t(1,25) = 2.12, p < .05$, respectively].

Errors. The error rates were analyzed as for the RTs. A two-way ANOVA revealed a main effect of congruency [$F(1,25) = 4.51, p < .05$], but no effect of display type ($F < 1$). More important, there was again a significant interaction between congruency and display type [$F(2,50) = 5.71, p < .01$]. As with the distractor effects found on RTs, the error rates also showed distractor congruency effects in the blank condition [$t(1,25) = 16.89, p < .01$], which were significantly reduced by the addition of an upright anonymous face [$t(1,25) = 3.98, p < .01$], but not by the addition of an inverted anonymous face ($t < 1$).

This experiment replicated the important aspects of Experiment 1. There was a congruency effect from the famous face distractor when this was the only distractor

Table 2
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects ($n = 26$) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 2

	Distractor Condition						Effect Size (I − C)	
	I			C				
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Blank	530	16	22	491	16	19	39	3
Inverted	533	18	21	503	16	20	30	1
Intact	520	15	20	514	18	21	6	−1

Note—I, incongruent; C, congruent.

present. This effect was significantly diluted by the addition of an intact anonymous face, but not by the addition of an inverted anonymous face, even though the latter was similar to the intact face in all aspects except for the ease of face processing for it.

EXPERIMENT 3

The previous two experiments demonstrated that face–name interference can be diluted by the presence of another intact face, but not by a phase-shifted stimulus or an inverted face. These findings suggest that the congruency effects produced by a distractor face are not due solely to the power of an isolated distractor to summon attention to its location on the basis of low-level stimulus energies (cf. Kahneman & Chajczyk, 1983; Yantis & Jonides, 1984). If this had been the case, *any* additional item with sufficient stimulus energy ought to have eliminated this effect, yet phase-shifted or inverted faces produced no such dilution when added to the critical distractor.

On their own, however, the first two experiments provide only preliminary support for distractor faces being *special*, in the sense that their effects are diluted only by adding another distractor from the same particular stimulus class of faces. It may be that intact faces were more effective in diluting the effects of the critical distractor simply because they are more meaningful objects than are phase-shifted or inverted faces. In choosing these nonface stimuli, we had sought to match them to faces in terms of low-level visual energies and features. Having established that such low-level properties are not the critical determinant of the observed dilution, any role for *meaningfulness* can now be examined by using meaningful nonface objects as the additional flankers (with the equating of low-level visual properties no longer being the primary concern).

Method

Subjects. The 30 new subjects (20 female) were again paid volunteers from University College London, whose ages ranged from 18 to 26 years. All reported normal or corrected vision and recognized the famous faces they were to encounter in the experiment.

Stimuli and Procedure. The stimuli and procedure were the same as those in Experiment 2, except as follows. The set of inverted faces was replaced by a set of meaningful photographed objects (six items of fruit and vegetables and six musical instruments). By analogy with the anonymous faces of the previous studies, we chose objects that were difficult to name (e.g., rambutan, durian, zither, dulcimer), while remaining easy to categorize at the basic level. The subjects completed six blocks of 96 trials, composed of 48 displays with a meaningful object as the additional flanker and 48 displays with an upright anonymous face as the additional flanker, intermingled randomly within each block.

Results and Discussion

As for the previous experiments, incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were filtered from the RT data. Data from 1 subject whose error rate was 23% (more than 2 *SD*s from the group mean) were also excluded from the analyses. The RTs and error rates (averaged across subjects) for each level of congruency and display type are shown in Table 3.

RTs. A two-way ANOVA (congruency [2] × display type [2]) on RT data revealed a main effect of congruency [$F(1,28) = 40.65, p < .01$], with faster responses to congruent displays. Once again, there was no main effect of display type ($F < 1$), but the main effect of congruency was critically modified by a significant interaction with display type [$F(1,28) = 3.34, p < .05$]. As can be seen from Table 3, this interaction arose because, although some congruency effect was found in the presence of both types of additional flankers [$t(1,28) = 4.31, p < .01$, for faces; $t(1,28) = 5.25, p < .01$, for objects], this effect was smaller in trials with an anonymous face than in trials containing a meaningful nonface object.

Errors. Analogous analyses of error data revealed a main effect of congruency [$F(1,28) = 26.49, p < .01$], with a higher error rate for incongruent trials than for congruent trials. There was also a main effect of display type [$F(1,28) = 3.45, p < .05$] and an interaction between congruency and display type [$F(1,28) = 3.66, p < .05$]. This interaction had a pattern similar to that found in the RT data. Congruency had a significant effect on error rates for both types of additional flankers [$t(1,28) = 2.00$, $p < .05$, for faces; $t(1,28) = 4.31, p < .05$, for objects], but the congruency effect was smaller when the additional flanker was an anonymous face rather than a nonface object, just as in the RT data. Thus, the additional distractor face produced significantly more dilution of effects from the famous face distractor than did an additional nonface object, for both RT and error rate measures.

Table 3
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects ($n = 29$) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 3

	Distractor Condition						Effect Size	
	I			C			(I − C)	
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Object	482	21	12	443	19	8	39	4
Face	470	23	10	446	22	8	24	2

Note—I, incongruent; C, congruent.

EXPERIMENT 4

The next experiment again compared dilution of congruency effects from the famous face distractor when an anonymous face versus a nonface object was added as the potential diluter. A *blank* condition was now also included (i.e., with no additional distractor, but with just the famous face, as in Experiments 1 and 2), to provide a baseline for assessing any impact of the nonface object.

Method

Subjects and Apparatus. The 30 new subjects (22 female) were paid volunteers from the University of Glasgow, whose ages ranged

Table 4
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects (*n* = 29) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 4

	Distractor Condition						Effect Size (I − C)	
	I			C				
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Blank	561	17	13	500	14	8	61	5
Object	560	18	14	512	15	8	48	6
Face	542	16	13	517	16	8	25	5

Note—I, incongruent; C, congruent.

from 18 to 21 years. All reported normal or corrected vision and recognized the famous faces they were to encounter in the experiment.

Stimuli and Procedure. The stimuli and procedure were the same as those in Experiment 3, except for the inclusion of a blank condition. Each block of 144 trials was now composed of 48 displays with a meaningful object as the additional flanker, presented concurrently with the famous face, 48 displays with an upright anonymous face as the additional flanker, and 48 displays with no additional flanker (blank; only the famous face was present as a distractor), all in intermingled order.

Results and Discussion

As for the previous experiments, incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were filtered from the RT data. Data from 1 subject whose error rate was 30% (more than 2.8 *SD*s from the group mean of 11%) were also excluded from analyses. The RTs and error rates (averaged across subjects) for each level of congruency and display type are shown in Table 4.

RTs. A two-way ANOVA (congruency [2] × display type [3]) on the RT data found a main effect of congruency [$F(2,28) = 99.41, p < .01$], with faster responses to congruent displays, but no reliable main effect of display type [$F(2,56) = 2.83, p = .07$]. The main effect of congruency was once again modified by the critical interaction with display type [$F(2,56) = 7.93, p < .01$]. As can be seen from Table 4, the critical famous face distractor produced some congruency effects in all conditions ($p < .01$ in each case), but these distractor effects were significantly smaller in the condition with an added anonymous face than in either the condition with an added meaningful nonface object [$F(1,28) = 2.52, p < .05$] or the blank condition, in which there was no additional distractor [$F(1,28) = 3.92, p < .01$]. There was no significant difference in distractor effects between the blank and the nonface object conditions [$F(1,28) = 1.39$, n.s.].

Errors. Analogous analyses of the error data revealed only a main effect of congruency [$F(1,28) = 50.39, p < .01$], with a higher error rate for incongruent trials than for congruent trials. There were no other effects in the analysis of error rates ($p > .1$ for all comparisons).

Thus, the addition of an irrelevant anonymous face to the display again caused significant dilution of interference effects from the critical distractor face, this time relative to both (1) displays containing no additional distractor and (2) displays containing an additional nonface object. As with the phase-shifted or inverted face stimuli used in Experiments 1 and 2, the addition of a meaningful nonface object to the display here produced no significant dilution of congruency effects from the famous face distractor, as compared with the baseline blank condition. These results for interference from famous faces appear to contrast with Kahneman and Chajczyk's (1983) results for interference from distractor words, where interference in a color-naming task was diluted by the addition of *any* other stimulus to the array. In our next experiment, we examined whether congruency effects from distractor photographs of three-dimensional (3-D) nonface objects would be analogously diluted by the addition of any type of distractor, unlike the effects observed for photographs of faces.

EXPERIMENT 5

In this experiment, we examined congruency effects (and any dilution of these) from photographed 3-D *nonface objects*, in a task in which their categories now became task relevant, so that photographed objects now took the role previously played by the famous face distractors.

The subjects were asked to categorize printed object names as fruits versus musical instruments, while again trying to ignore irrelevant flanking distractor photographs. The critical *object* distractor and target word could be either congruent (e.g., a photograph of a piano, used for the distractor, and the name *piano*, used for the printed central target) or incongruent (e.g., a photograph of an apple, with *piano* as the target name). The displays could contain (1) no other flanker (the blank condition), (2) an additional intact anonymous flanker face (the intact condition), or (3) an additional phase-shifted flanker generated from an anonymous face (the phase-shifted condition; see Figure 2). The possible types of additional distractors were, thus, the same as those in Experiment 1, but the task now concerned the names of nonface objects (not of people). Moreover, the critical distractor whose congruency with the target was manipulated was now a nonface object (i.e., a fruit or a musical instrument), rather than a face.

We hypothesized that congruency effects from photographed nonface distractor objects should be diluted by any other distractor stimulus, regardless of its nature (as is apparently the case for distractor words; Kahneman & Chajczyk, 1983). If so, we should find a congruency effect in the blank condition that would be significantly diluted by the presence of either a face or a phase-shifted face, and to an equivalent extent. Note that such a result would differ from that previously found here for congruency effects from famous faces, where dilution was highly specific to an additional intact face (see Experiments 1–4). If congruency effects from nonface objects are diluted only by objects of a similar (i.e., nonface) type, no dilution should be caused by adding

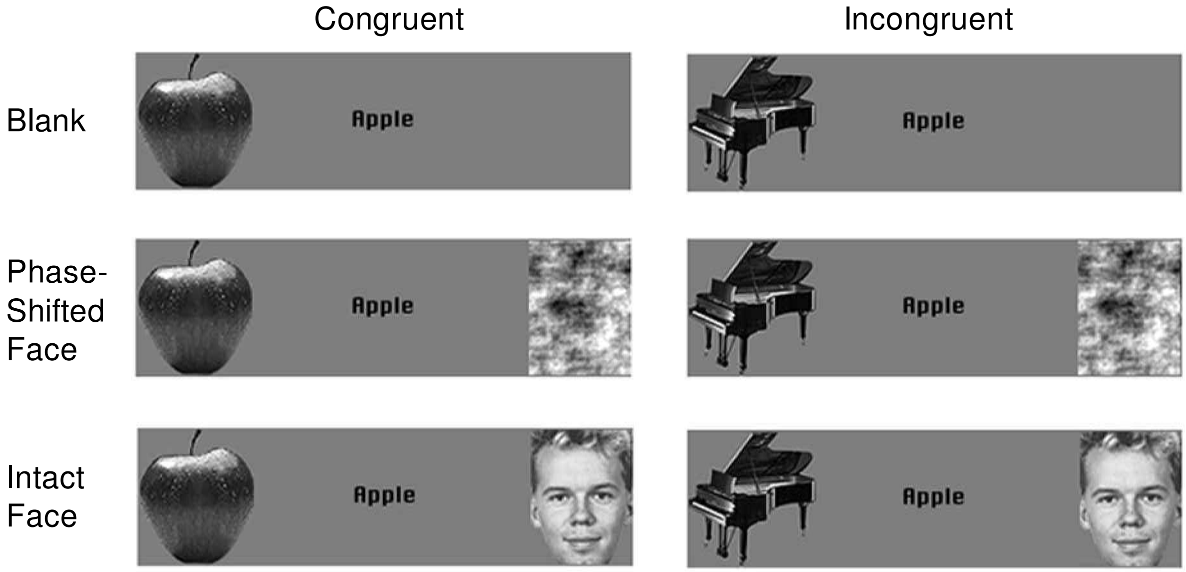

Figure 2. Example displays from the six conditions in Experiment 5.

either an intact or a phase-shifted face. Finally, if distractor faces are always more disruptive to the processing of other distractors, regardless of the task or of the type of distractor whose influence is being diluted, adding an intact face should again produce more dilution than the phase-shifted face (as in Experiment 1).

Method

Subjects. The 25 new subjects (15 female) were paid volunteers from University College London in the age range of 18–30 years, who reported normal or corrected vision. A test at the beginning showed that the subjects were able to name the photographed fruits and musical instruments they were to encounter in the experiment.

Stimuli and Procedure. The stimuli and procedure were the same as those in Experiment 1, except for the following changes. The target set now consisted of 12 common object words. Six were names of musical instruments (accordion, drums, guitar, piano, saxophone, and violin), and 6 were names of fruits (apple, banana, orange, pear, pineapple, and strawberry). As in the previous experiments, target words were presented in black 12-point Arial font, with all letters except the first in lowercase. The longest word was 2.7 cm wide (subtending a visual angle of 2.6º), and the shortest was 1.1 cm (1.1ºof visual angle). The critical distractors (i.e., those that had a possible congruent or incongruent relation to the target response) were now photographic grayscale images of the 12 objects whose names served as targets. These object images measured between 1.8 and 2.8 cm horizontally and 2.8 cm vertically (1.7º–2.7º × 2.7º of visual angle). As in Experiment 1, there were three display types. The target and critical distractor could appear (1) unaccompanied (blank condition), (2) accompanied by an intact flanker face (intact condition), or (3) accompanied by a phase-shifted stimulus that had been generated from an anonymous face (phase-shifted condition; see Figure 2). The additional flankers were drawn from the 12 intact anonymous faces and 12 phase-shifted anonymous faces of Experiment 1. Again, the nearest distractor contours were 1.2 cm (1.1º of visual angle) away from the central target name. After an example block of 12 trials and a practice block of 72 trials, the subjects completed seven blocks of 72 trials.

Results and Discussion

Table 5 shows the mean correct RTs and error rates for each level of critical distractor congruency and additional flanker type. Once again, incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were excluded from the RT data. Data from one subject whose error rate was 34% (2.9 *SD*s from the group mean) were also excluded from the analyses.

RTs. As in the previous experiments, a two-way ANOVA (congruency [2] × display type [3]) on the mean RT data found a main effect of congruency [$F(1,23) = 39.25$, $p < .01$], with slower responses to incongruent displays, but no main effect of display type ($F < 1$). Once again, the main effect of congruency was modified by an interaction between congruency and display type [$F(2,46) = 3.65$, $p < .05$].

Planned comparisons on this interaction revealed that although the congruency effect was significant in each of the additional flanker conditions ($p < .01$ in all cases), it was significantly smaller when either an intact or a

Table 5
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects ($n = 24$) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 5

	Distractor Condition						Effect Size (I − C)	
	I			C				
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Blank	416	19	12	363	18	8	53	4
Phase shifted	400	20	11	374	15	8	26	3
Intact	401	18	10	368	17	7	33	3

Note—I, incongruent; C, congruent.

phase-shifted anonymous face was added to the display than when no additional flanker was added [$t(1,23) = 2.29, p < .05$, and $t(1,23) = 2.73, p < .05$, respectively]. Furthermore, the congruency effects in the phase-shifted versus intact face conditions were not significantly different from each other ($t < 1$).

Errors. Similar analyses of the error rates showed only a main effect of congruency [$F(1,23) = 22.39, p < .01$]. There were no other effects in the analysis of error rates ($p < 1$ for all), but note that any numerical trend was for a larger congruency effect in the blank condition, in agreement with the RT pattern.

This pattern of dilution is qualitatively different from that seen in the four preceding experiments. As before, interference from the critical distractor was significantly reduced by adding an intact anonymous face to the display; but for the first time, the addition of a nonface (i.e., phase-shifted) flanker also produced significant dilution, and to an equivalent extent. We note that this pattern, of significant dilution of congruency effects from nonface objects by any additional stimulus, regardless of its type, is consistent with that found for congruency effects from words by Kahneman and Chajczyk (1983) but that it contrasts with the pattern found for the congruency effects from famous faces observed in Experiments 1–4 above. Moreover, this qualitative contrast in results between Experiment 1 and Experiment 5 seems resistant to any explanation in terms of task relevance, or *contingent* attentional capture (see, e.g., Folk, Remington, & Johnston, 1992), since the phase-shifted stimuli were presumably equally irrelevant, in both experiments, to the task of categorizing printed words, whether these concerned the printed names of famous people (Experiment 1) or the printed names of fruits and musical instruments (Experiment 5).

EXPERIMENT 6

The preceding experiment showed that, unlike congruency effects from a distractor face, congruency effects from a nonface distractor can be diluted equivalently by an added face or an added phase-shifted stimulus. However, it might be argued that neither of these two types of diluters closely resembles the type of nonface distractor that produced the congruency effect. For example, the phase-shifted stimulus has little perceivable structure and is not recognizable. It thus remains possible that a more meaningful (but still response neutral) nonface object might produce more dilution of object interference than would an added face. If so, congruency effects from nonface objects might then be diluted the most by other nonface objects (logically analogous to our previous findings that effects from faces are diluted the most by other faces).

In our final experiment, we tested this possibility by comparing the ability of a meaningful nonface object, versus an intact anonymous face, to dilute congruency effects from a nonface distractor object. As in Experiment 5, the subjects categorized printed object names as fruits or musical instruments, while trying to ignore a critical flanking distractor object that could be congruent or incongruent with the target response. The displays could now contain (1) no other flanker (the blank condition), (2) an additional intact anonymous face (the face-diluter condition), or (3) an additional, meaningful nonface object (the object diluter condition). We note that, as in all the preceding experiments, in order for congruency effects from the *critical* distractor (a nonface object here) to be interpretable, any *additional* distractor had to be response neutral. That is, it could not be drawn from the same category as the target word (here, musical instruments and fruits, playing analogous roles to pop stars and politicians in Experiments 1–4), since otherwise it would have its own congruency relationship with the target response. For this reason, we could not use the particular nonface objects (musical instruments and fruits) that had been used in Experiments 3 and 4 as *additional* distractors here. Instead, we now used pictures of household items (e.g., clock, telephone) as the additional nonface objects.

Method

Subjects. The 30 new subjects (21 female) were paid volunteers from the University of Glasgow in the age range of 18–20 years, who reported normal or corrected vision and were able to name the photographed fruits and musical instruments they were to encounter in the experiment.

Stimuli and Procedure. The stimuli and procedure were the same as those in Experiment 5, except for the following changes. The set of 12 phase-shifted stimuli was replaced by a set of 12 everyday nonface objects (bed, blender, chair, clock, colander, cooker, footstool, iron, lamp, telephone, toaster, and wardrobe). These meaningful but response-neutral nonface objects measured between 2.0 and 2.5 cm horizontally and 2.8 cm vertically (1.9°–2.4° × 2.7° of visual angle). As in Experiment 5, the subjects completed an example block of 12 trials and a practice block of 72 trials, followed by seven blocks of 72 trials.

Results and Discussion

Table 6 shows the means across subjects for correct RTs and error rates for each level of critical distractor congruency and additional flanker type. As before, incorrect responses and RTs exceeding 2 sec (fewer than 2% of the correct responses) were excluded from the RT data. Data from 1 subject whose error rate was 17% (more than 2 *SD*s from the group mean) and 1 subject whose error rate reached 27% (more than 3 *SD*s from the group mean) were also excluded from the analyses.

RTs. As in the previous experiments, a two-way ANOVA (congruency [2] × display type [3]) on the mean RT data found a main effect of congruency [$F(1,27) = 48.90, p < .01$], with slower responses to incongruent displays, but no main effect of display type [$F(1,27) = 1.39, p > .20$]. Once again, the main effect of congruency was modified by the critical interaction between congruency and display type [$F(2,54) = 3.43, p < .05$].

Planned comparisons on this interaction revealed that although the congruency effect was significant in each

Table 6
Mean Reaction Times (RTs, in Milliseconds), Standard Errors (*SE*s), and Percentage Error Rates (%Es) Across Subjects ($n = 28$) as a Function of Distractor Congruency and Neutral Flanker Type in Experiment 6

	Distractor Condition						Effect Size (I − C)	
	I			C				
Neutral Flanker	RT	*SE*	%E	RT	*SE*	%E	RT	%E
Blank	495	16	8	453	17	6	42	2
Object	480	16	8	455	16	5	24	3
Face	481	14	8	454	15	5	27	3

Note—I, incongruent; C, congruent.

of the conditions ($p < .01$ in all cases), it was significantly smaller when either an anonymous face or a meaningful nonface object was added to the display than when no additional flanker was added [$t(1,27) = 2.04$, $p < .05$, and $t(1,27) = 2.44$, $p < .05$, respectively]. Critically, there was no significant difference in congruency effects between the face diluter and the object diluter conditions ($t < 1$).

Errors. As in Experiment 5, analyses of error rates found only a main effect of congruency [$F(1,27) = 19.37$, $p < .01$], with more errors to incongruent displays. There were no other effects in the analysis of error rates ($p > .10$ for all comparisons).

This experiment replicated the important aspects of Experiment 5, showing similar dilution of congruency effects from object distractors by (response neutral) faces and (response neutral) nonface objects alike. It extended this finding to the critical case of dilution by meaningful and well-structured nonface objects. This pattern of equivalent dilution by faces and objects is consistent with the notion that processing of a critical nonface distractor object can be similarly disrupted by any additional stimulus in the display, regardless of its type. This contrasts qualitatively with the pattern found repeatedly (Experiments 1–4) for congruency effects from a critical face distractor, which were diluted only by adding an additional upright (but still response neutral) face, not by adding nonface objects.

As was noted in the introduction to Experiment 6, the additional distractors that serve as potential diluters must always be unrelated to the response categories in the word categorization task, for all of the experiments in the present paper. (Otherwise, the additional distractors might produce congruency effects of their own, rendering any congruency effects from the critical distractors uninterpretable.) This constraint necessarily imposes a possible asymmetry between our experiments focusing on congruency effects from face distractors and those focusing on congruency effects from nonface object distractors. Specifically, in Experiments 1–4, adding anonymous face distractors provided *within* visual category diluters for the famous face distractors (i.e., the additional distractors fell within the same general visual category as the famous faces but were neutral with respect to the response categories of pop stars vs. politicians). However, there are logically no analogous *within visual category* yet response-neutral diluters for the response categories of fruits and musical instruments studied in Experiments 5 and 6, so the additional distractors in those studies (i.e., faces and household objects) arguably always provided *between* visual category diluters for the nonface distractors (assuming that household objects vs. fruits or musical instruments are indeed distinct visual categories).

We observed that congruency effects from nonface distractors were clearly diluted by the presence of between-category distractors; but it does remain theoretically possible that within-category objects would have produced even greater dilution effects. This could not be tested with the response competition paradigm used in the present research, owing to the constraints on response associations involved (as was explained above). Note, however, that this restriction does not alter the qualitative contrast in the effects of between-category diluters for face versus nonface distractors. Thus, although distractor interference from nonface stimuli, such as words (Kahneman & Chajczyk, 1983) on other nonface objects (e.g., fruits and musical instruments in our Experiments 5 and 6), can apparently be diluted significantly by the addition of any visual stimulus, interference from famous distractor faces can be diluted only by the addition of another intact (upright) face to the display, as we found in Experiments 1–4. In those experiments, between-category diluters (nonface objects, or inverted or phase-shifted faces) produced no impact on the congruency effects from famous faces, unlike the effects of between-category diluters on congruency effects from nonface objects.

GENERAL DISCUSSION

In the present study, we sought to determine the conditions under which an irrelevant but famous face can be ignored sufficiently to eliminate congruency effects from it. Our first four experiments confirmed that an irrelevant photographed famous face can produce congruency effects in a task (similar to Young et al., 1986) requiring the categorizing of famous names, despite a clear spatial separation between the central name and the more peripheral face. These distractor effects from famous faces were unaffected by the addition of another, “nonface” stimulus to the display (e.g., a phase-shifted version of a face in Experiment 1, an inverted face in Experiment 2, or a meaningful nonface object in Experiments 3 and 4). The interference from a famous distractor face was diluted only by the addition of an intact anonymous face to the display, which consistently reduced the interference effect in Experiments 1–4.

By contrast, in Experiments 5 and 6, we found that congruency effects from an irrelevant photographed nonface *object* (e.g., a fruit), in a categorization task for object names (i.e., classifying printed words as fruits vs. musical instruments), was diluted not only by use of an intact face as an additional distractor (in Experiments 5 and 6), but also by a phase-shifted face (Experiment 5) or a meaningful nonface object (e.g., a clock; Experiment 6), and to the same extent. The results for Experiments 5 and 6 thus differ from those found for face interference in Experiments 1–4 but accord with previous findings (Kahneman & Chajczyk, 1983) that interference from distractor words can similarly be diluted by adding any stimulus to the display, even a nonsense stimulus. Thus, whereas distractor interference from nonface stimuli, such as words and other objects (e.g., fruits and musical instruments in our Experiments 5 and 6), can apparently be diluted by the addition of any visual stimulus, interference from famous distractor faces can be diluted only by the addition of another intact (upright) face to the display, as we found in Experiments 1–4.

These results have several implications. Although face processing may be *automatic* in the sense of arising involuntarily for a single famous distractor face (Young et al., 1986), such processing is evidently not entirely capacity free, since adding a second (anonymous) face can dilute the effect of the famous face. Moreover, this capacity limit for faces seems more specific than those for other classes of objects, whose interference may be diluted by adding any type of object to the display, since only another intact face can dilute the effect of a famous face.

One way to explain this difference between dilution of face interference and dilution of interference from other types of distractors would be to argue that faces are particularly strong competitors for attention, as compared with other stimulus classes (see Ro, Russell, & Lavie, 2001, for a similar claim). If so, the famous face would inevitably prove distracting when competing against another type of object. Only another intact face would be able to compete on equal terms against it. On this view, processing of the famous distractor face is diluted only by another face because faces are particularly distracting stimuli. One aspect of our results, however, seems inconsistent with any simple generalization that faces are always more powerful distractors than are other classes of stimuli. In Experiments 5 and 6, an intact face produced no more dilution than did either a phase-shifted version (Experiment 5) or a meaningful nonface object (Experiment 6) upon interference from a critical nonface object. It thus appears that although an added intact face produces some *special* diluting effect upon interference from another face, it does not do so for interference from a nonface object.

This could be explained by supposing that the capacity limit revealed by dilution of interference from famous faces is category specific. If congruency effects from a famous distractor face depend on truly face-specific processes, only an additional face will load that process. For instance, a neural system that responded only to intact faces would be unaffected by the addition of a nonface object. Viewed from this perspective, the present results provide psychological evidence that converges with recent proposals in neuroscience and neuropsychology for face-specific processes (e.g., Farah, Wilson, et al., 1995; Kanwisher et al., 1997). The fact that dilution effects for interference from distractor words (Kahneman & Chajczyk, 1983) and distractor objects (our Experiments 5 and 6) are less specific to the type of added stimulus implies that limits in their processing may depend less on specific capacities, and more on general capacity, than do limits for the processing of faces. Processing of an irrelevant word or object can apparently be reduced by the presence of any competing distractor (among the several types studied so far), whereas processing of a famous face can apparently be reduced only by the presence of another intact face. These experiments thus support the idea that face processing is conducted by a dedicated system with its own capacity limits, so that interference from a distracting famous face will be particularly difficult to eliminate unless other faces are present.

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