Repetition Priming of Face Gender Judgments: An Instance Based Explanation

DENNIS C. HAY

Lancaster University

Correspondence concerning this article should be addressed to Dennis Hay, Department of Psychology, Fylde College, Lancaster University, Bailrigg. Lancaster, England, LA1 4YF, D. Hay@lancaster.ac.uk

ABSTRACT

Earlier studies of repetition priming using faces have been interpreted as indicating that such effects are confined to the processing of known faces. The experiment reported here employed 8 rather than the more usual 2 presentation trials and required subjects to make gender decisions (is it a male or is it a female face?) to both familiar and unfamiliar faces. This allowed the currently favoured recognition unit theories of face processing to be compared with the Logan (1988) instance model. Equivalent repetition priming effects were observed for both familiar and unfamiliar faces and were well fitted by power functions. It is argued that the findings are consistent with the strong predictions made by Logan's model and pose problems for recognition unit based theories.

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Current theoretical models of face recognition distinguish between the sets of processes needed to extract basic information common to all faces (e.g. gender, age, expression, transformations across pose, etc.) and the processes required to recognise and retrieve information about known faces. For example, in the Hay and Young (1982) model, the Bruce and Young(1986) model and the Burton, Bruce and Johnson (1990) neural network simulation, knowing a face is familiar requires activation of a face recognition unit (FRU), which in turn allows access to semantic information and finally access to name retrieval. Common to these serial access models is the concept of an FRU; a device containing both the “essence” of a known face and a set of procedures for matching incoming facial information with this stored internal representation. These can best be described as *abstraction* models in which the ‘essence’ of a face is abstracted from the variety of exposures to this face and requires the discarding of the individuating characteristics of any particular instance of a known face. FRU’s, therefore, are direct equivalents of the logogens proposed by Morton (1979) to explain how words are recognise.

One of the main sources of evidence that has been used to examine the validity of FRU based functional models has come from experiments using a repetition priming methodology (Bruce and Valentine 1985; Ellis, Young, Flude and Hay 1987). The results from these studies and the finding that expression and gender decisions to photos of famous and unfamiliar faces speeded subsequent familiarity decisions, led Ellis, Young and Flude (1990) to conclude that repetition priming is confined to the processes invovled in processing familiar faces and not other forms of face processing. In a recent integrative study Ellis, Flude, Young and Burton (1996) identified two loci at which repetition priming in processing faces operates. The first involves perceptual recognition of a face as familiar and is in their view domain specific by which they mean that it is restricted to classes of stimuli having a specialised recognition system (Baddeley, 1982). That is, previous exposure to a famous face will prime later presentations of the same photograph or other similar views but will fail to prime the name of that celebrity. The second locus is at the stage of name retrieval and is domain independent. Thus, previously reading aloud the name of a celebrity will prime the subsequent naming of the face of that celebrity. In a series of experiments Ellis et al. showed that tasks involving familiarity or occupational decisions are susceptible to locus 1 priming effects while locus 2 priming is observed in tasks involving face naming.

Ellis et al. (1996) argue that the existing face priming data support what they term to be *structural theories* of face repetition priming in which response time speed up on the second viewing of a known face is a reflection of the structural change in the activation unit threshold which is lowered by the initial presentation of the face. They also argue that the data pose significant problems for alternative theoretical accounts in which the internal representation are not FRU abstractions but based on the storage of instances or episodes (e.g. Jacoby, 1983 and Jacoby and Brooks, 1984) and suggest repetition priming results from a process of *perceptual enhancement* where the memory of a previous encounter with a stimulus facilitates its recognition. Ellis et al. direct their criticisms towards one particular instance-based account, that of Logan (1990), which attempted to draw parallels between repetition priming and the development of automaticity in task performance following large amounts of practice.

In the Logan model there exist a basic set of algorithms capable of processing stimuli and that the algorithm used to process a novel face has an associated response time(RT) distribution. Each encounter with a face generates a stored representation and each of these *instances* also has an associated RT distribution. Subsequent recognition is accomplished by a processing race in which all existing instances race against one another and the basic algorithm.

Logan (1988) has shown that simulating the race model over a range of algorithm and instance parameters always leads to RT functions which are well fitted by power functions of the form;

$$RT = a + b\,(\text{Instance})^{-c}$$

where a is the function asymptote, b a measure of the difference between initial and asymptotic performance and c the learning rate.

Hay (in prep) extended these findings by showing that RT data from a face repetition priming task in which subjects made familiarity decisions (deciding if a stimulus face was of a famous celebrity or of a previously unknown person) to the same faces on eight trials also produced power functions of this form. In addition, the data also supported a number of strong predictions made by the Logan instance model, namely:

(a) that mean correct RT performance and the variability in performance, as measured by the standard deviation, reduce as the number of trials increase and that both are well fitted by power functions with the above form,

(b) that the mean and the standard deviation power functions share the same exponent,

and,

(c) that different quantiles of the RT processing distribution are also well fitted by power functions and that these also share the same exponent as the mean and standard deviation functions.

These data offer strong support for an instance based account of face repetition priming and pose serious problems for the abstraction models based on FRUs and explain priming as due to the lowering of an FRU activation level on the first encounter with a known face. These are not well enough specified to make any predictions about the amount of speed-up in RT which should result. In addition, Hay found power function RT speed-up for both the familiar and the initially unknown faces. The latter speed-up is particularly problematic for current abstractive accounts as priming is based on the functioning of FRU's which only exist for known faces.

However, Ellis et al. (1996) also point out that certain properties of locus 1 priming (i.e., recognising that a face is familiar) are difficult for Logan's instance model to explain. For example, they cite the Ellis, Young and Flude (1990) study showing that only certain types of face decision are subject to repetition priming. Gender decisions (is this a male or female face?) show no priming even when the same photo of a familiar face is seen minutes earlier. Instance models, they argue, predict priming as the second presentation should lead to the activation of the previous instance leading to better performance. There are, however, a number of reasons why Logan's instance model can explain and even predict when such tasks should and should not produce priming. First, in the Logan scheme, an instance relates not to the stimulus alone but to the context in which it is experienced and the response made. Only instances that are sufficiently similar are accessed. In the Ellis et al. (1990) study subjects generated semantic statements to the stimulus faces on the first occasion while making speeded binary- choice, sex or expression decisions on the second occasion. Thus the two instances require different types of decision and different response outcomes making it debatable whether the prior instance was useful and thus accessed.

Even in the Ellis et al. experiments when the context was identical it is still possible to define the conditions under which the instance model predicts priming. At the core of the model is a race between an algorithm - a base set of processes - and a set of instances residing in memory. The more instances existing in memory the greater the chance that an RT sample from one of the instance distributions will be the minimum value and win the race. However, it appears that the gender algorithmic processing is fast - in the Ellis et al. study gender decisions on the first occasion were below 650 ms - so priming by a single previous instance is only likely if the instance RT distribution mean is lower. The instance model does predict that speed-up will be observed with increasing numbers of instances irrespective of the distributional parameters (Logan 1988).

The present study sets out to examine certain predictions made by the Logan instance model. In particular whether priming does occur with more than one repetition and whether the strong predictions made concerning the observation of power curves for the indices of performance RT and their relationship hold for making gender decisions for faces.

METHOD

Subjects

Fifteen psychology students from Lancaster University acted as subjects. All had normal or corrected vision, and had been exposed for a minimum of five years to the British media. They ranged in age from 19 - 32 years and were paid for participating in this experiment.

Stimuli and Materials

Video clips of a range of celebrities were collected from TV productions. Each was around 2 minutes duration and contained a range of head movements and expression changes. From these twenty-three celebrities were selected to sample as wide a range of interests as possible. Twenty, ten males and 10 females, were used as experimental stimuli and three were used on the lead-in trials. Similarly, clips of unfamiliar faces were collected from German and Dutch TV programmes and films in an attempt to equate the quality and range of faces.

Twenty of these were selected to match the chosen celebrities on age, facial hair and spectacle use and three for the lead-in trials.

These video clips yielded eight monochrome images that were “frame-grabbed” using the QuickImage system. The images selected for each individual ranged from three-quarter right, through full face, to three-quarter left pose and contained a variety of facial expressions. The selected images were then standardised by first cropping the image to maximise the amount of facial information while minimising the amount of background and clothes. Images were then standardised in size (6.5 cm x 4 cm) and equated in brightness and contrast using Adobe Photoshop software on a Macintosh computer.

The stimuli were presented on Macintosh LCII computers with colour monitors. These were viewed at approximately eye level (i.e. the centre of the screen was 35 cm above the height of the desk at which subjects were seated) and situated behind a black screen situated approximately 60 cm from the subject that allowed only the monitor to be viewed. Subjects made their response by pressing one of two buttons on a box positioned on the desk in front of the subject. The buttons were interfaced to the computer and simulated a single key press of two particular keys (in this case lower case t and o). A filler task was to be used between experimental blocks to ensure subjects had short breaks. This task involved rating words and non-words using a seven page booklet. Each of the eight pages contained eight letter strings to be rated on several scales.

Experimental Design

The experimental design and stimulus presentation was handled by the SuperLab application for Macintosh computers. Subjects first viewed two screens of instructions before completing four practice trials, two of which presented images of celebrities and two of unfamiliar persons. These were followed by a screen listing the key instructions for the experiment and informing subjects that they now had an opportunity to ask questions.

There then followed an experimental block consisting of six lead in trials (the data from which did not enter into the analyses) and forty experimental trials. Both the lead in trials and the experimental trials were randomised before each presentation and subjects viewed the experimental block eight times. After each experimental block subjects were required to complete one of the pages of the word booklet.

The background colour of the screen for each of the lead in and experimental trials was a pale blue upon which the word “ready” appeared in red and in letters approximately 1.5 cm tall. This was displayed for 2000 msecs in the centre of the screen and replaced after a 500 msecs blank screen with a central red dot. This was presented for 500 msecs and again followed by a 500 msecs blank screen. A stimulus face was then presented centrally for 2500 msecs and subjects responded by pressing one of the two buttons. A further 1000 msecs blank preceded the presentation of the next “ready” signal that indicated the start of the next block. After each block instructions appeared instructing the subjects to fill in the one of the pages of the word booklet.

Procedure

Subjects sat at a desk facing the monitor and were instructed to place the index finger of each hand on the two buttons and to locate the button box in a comfortable position in front of themselves. They were then asked to read the instructions presented on the screen. These indicated that the experiment was designed to investigate how male and female faces are processed and that a series of faces was to be presented some of which would be of famous faces and some of unfamiliar faces. Subjects were instructed to decide if a particular face was male or female and to indicate their decisions by pressing the appropriate button. They were asked to make decisions as quickly and as accurately as possible and to complete the practice trials. At the end of these the experimenter indicated what the correct responses were for the practice trials and asked if subjects had any questions. The experimenter then orally repeated the instruction to be as fast and as accurate as possible before allowing subjects to start the experiment proper. Each subject then completed eight consecutive experimental blocks separated by one page of the filler task booklet.

For half the subjects pressing the right button was used to indicate the image was of a celebrity and for half the mapping was reversed.

RESULTS

The analyses were of two forms. First analyses of variance (ANOVA's) were conducted on the response time (RT) data as this is the primary method used in previous face research to analyse differences in face processing. Second, power curve parameters were fitted to the data as a means of examining the validity of the instance-based model and to allow comparisons between the forms of analysis presented in this study and the series of studies, following Logan (1988).

ANOVA's of the Response Time Data

For each subject the RTs from the 20 male, of which 10 were famous faces and 10 were unfamiliar, and the 20 female faces and the errors were collected. These were processed to yield the mean correct RT and the standard deviation for each subject for each experimental condition. This generated a 2 x 2 x 8 within design (gender of face x familiarity of face x experimental block) and subsequent ANOVA revealed the main effect of gender to be significant with it taking 526 ms to identify a face as male compared to 548 ms to identify a face as female, F (1,29) = 7.51, MSE = 14852.84, $p < 0.05$. In addition, performance over the experimental blocks showed a practice curve decrease F (7,203) = 3.928, MSE =

5387.97, $p < 0.001$ (see Table 1). In order to compare these data with previous priming studies a number of additional planned comparisons were conducted. The data from Ellis et al. (1990) indicate no priming of gender decisions on a second gender decision trial. The current data indicate a drop in RT performance but in line with the Ellis et al. study this was found not to be significant. However a significant priming effect was found between trials 2 and 3, $F(1, 203) = 4.191$, MSE = 22581.3, $p < 0.05$. No other significant main effects or interactions were observed.

Power Curve Parameter Estimation

The instance theory detailed by Logan (1988,1992) makes two strong predictions. First, that data from conditions in which subjects make the same decision to the same stimuli in repeating blocks of trials are well fitted by power functions of the form;

$$\text{RT measure} = a + b(\text{Trial Block})^{-c}$$

Secondly, the mean and standard deviation power functions of the data from each type of face should be well fitted by power functions and have the same c parameter (Logan 1988).

The analysis strategy used to examine these predictions involved fitting power functions to various RT summaries. A number of different algorithms were employed including using the STEPIT algorithm (Chandler, 1965) used by Logan (1988,1992), Newton, Quasi-Newton, Steepest Descent algorithm (Raner, 1994) and the Levenberg-Marquard algorithm (Press, Flannery, Teukolosky & Vetterling; 1992). These all produced similar solutions. The prediction of common rate exponents was examined by constraining the c parameter to be equal across functions while allowing the other parameters to vary freely, and to select the common exponent that minimised the error fit statistics for the functions under consideration. The constrained fits could then be compared with the unconstrained fits as a means of examining the validity of the instance theory predictions (Logan 1988).

Power functions were fit to the overall mean correct RT and standard deviation data (see Figure 1) and the estimated parameters and the measures of goodness of fit are presented in Table 2. These clearly show that the data are well fitted by power functions of the form specified by Logan which explain the vast majority of the observed variance. Moreover, when the exponents for means and standard deviations were constrained to be the equal and to minimise the the resulting error measures, the decrease in explained variance was found to be minimal and non-significant for both the mean and the standard deviation data (see Table 2).

DISCUSSION

The results from the current experiment are unambiguous. It is clear that repetition priming does not depend solely on the identity processing system as reductions in processing speed for subsequent items is found for familiar and unfamiliar faces and that the degree of primng is equivalent for both classes of stimulus. In addition, the conditions under which repetition priming can be observed in gender decision making has been clarified. If only the first two trials are considered then the data replicate the findings of Ellis et al. (1990) by showing no evidence of repetition priming. However, in line with the predictions made by Logan's instance model, priming is in evidence with subsequent repetitions. Thus a change from algorithmic processing to instance based retrieval in gender decisions is only possible if sufficient instances exist. This, in turn, makes it statistically more likely for one of the instances to be retrieved before the fast algorithmic processing can be accomplished. In fact, performance on trial block one, which reflects only algorithmic processing, was found to be fast (562 ms) and reflects an efficient algorithm which is applied to the processing of all faces.

At a theoretical level, the results are difficult to encompass within current abstraction models which assume repetition priming occurs only within the system that stores representations of the appearance of familiar faces (Ellis et al. 1990, Ellis et al., 1996). In this experiment repetition priming was observed in a gender decision task and to be equivalent for both familiar and unfamiliar faces (see Figure 1) confirming previous observations of unfamiliar face priming (Bentin & Moscovitch, 1988; Hay, in prep.). In contrast, the data are entirely consistent with memory models which are episodic based (Jacoby, 1983) and particularly Logan's (1988) instance model which not only predicts power function repetition priming speed-up but can predict the conditions under which repetition priming can be observed in gender decision tasks.

Some form of integration, however, may be possible as the Burton et al. (1990) model is based on the interactive activation model suggested by McClelland and Rumelhart (1981). More recent and comprehensive versions of this seek to explain the development of what appear to be abstractive word and concept units as resulting from storage of all instances of the word or concept (McClelland and Rumelhart, 1985). Models such as these respond strongly to prototypical patterns while also responding strongly to recent instances in the training set. However adopting such a position involves embracing the concept of abstractions based on instances and viewing face priming as being dependent on the number of “appropriate” instances available on any task. This may also be important for attempts to explain how FRU are formed in the first place.

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TABLE 1

Mean and standard deviation of the correct response times for each trial block for all types of face used in the experiment.

Trial Block	**Mean RT**	**S.D. RT**
1	562	92.1
2	553	86.4
3	532	71.7
4	534	69.3
5	530	65.9
6	529	74.8
7	525	73.2
8	530	63.6

TABLE 2

Parameter estimates for the unconstrained and the constrained power functions ($RT = a + b\,(Block)^{-c}$) fitted to the means and the standard deviations of the correct response times. Also given are the goodness-of-fit measures and tests of the reduction in variance explained by the unconstrained and constrained fits.

	a	**b**	**c**	**R2**	**rmsd**	**F**	**p**
Mean RT	509	54	-0.56	0.905	116.03		
Constrained Mean RT	511	52	***-0.61***	0.905	116.28	0.004	> 0.05
S.D. RT	58	36	-0.65	0.777	151.79		
Constrained S.D. RT	57	36	***-0.61***	0.778	151.81	0.002	> 0.05

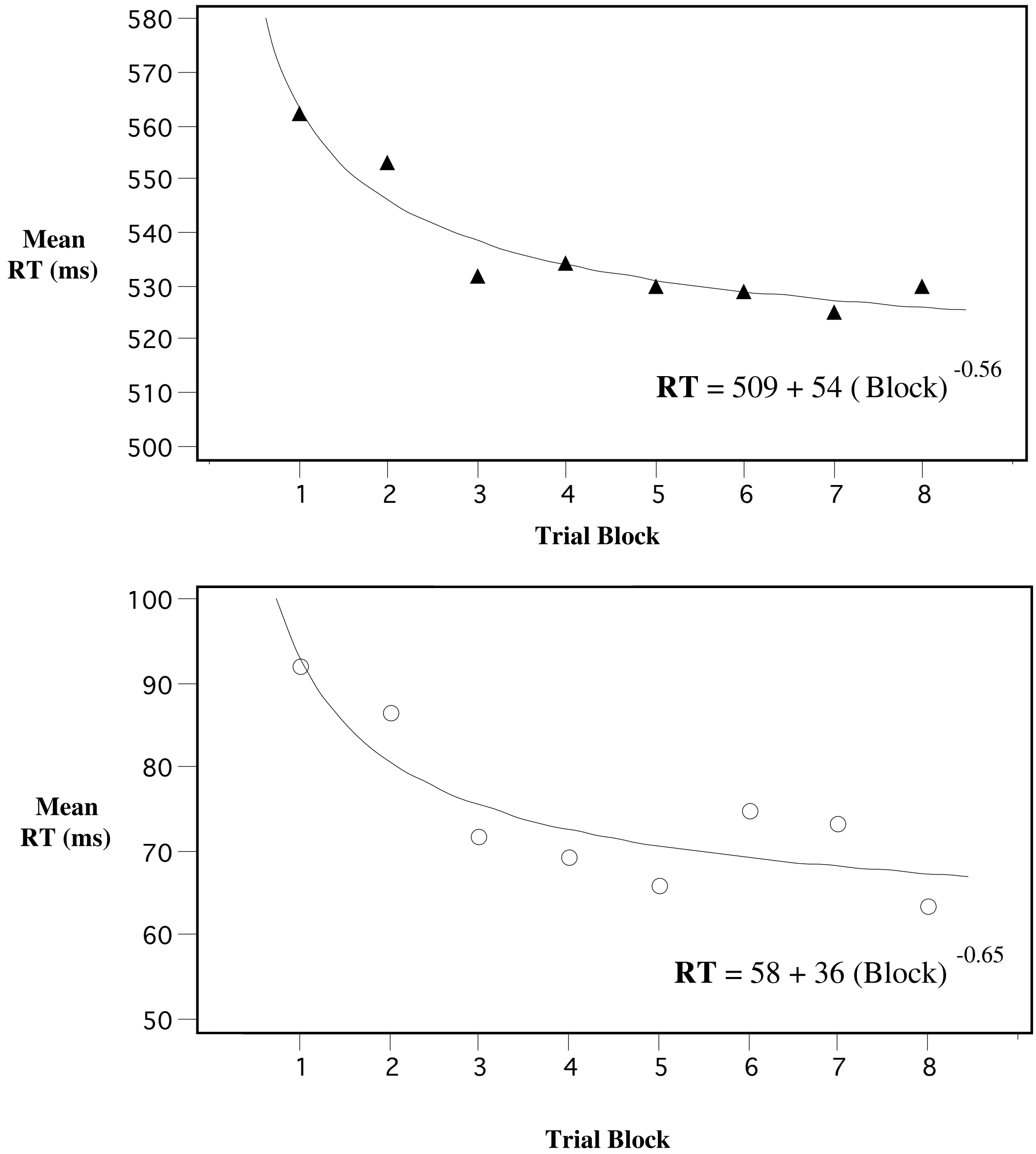
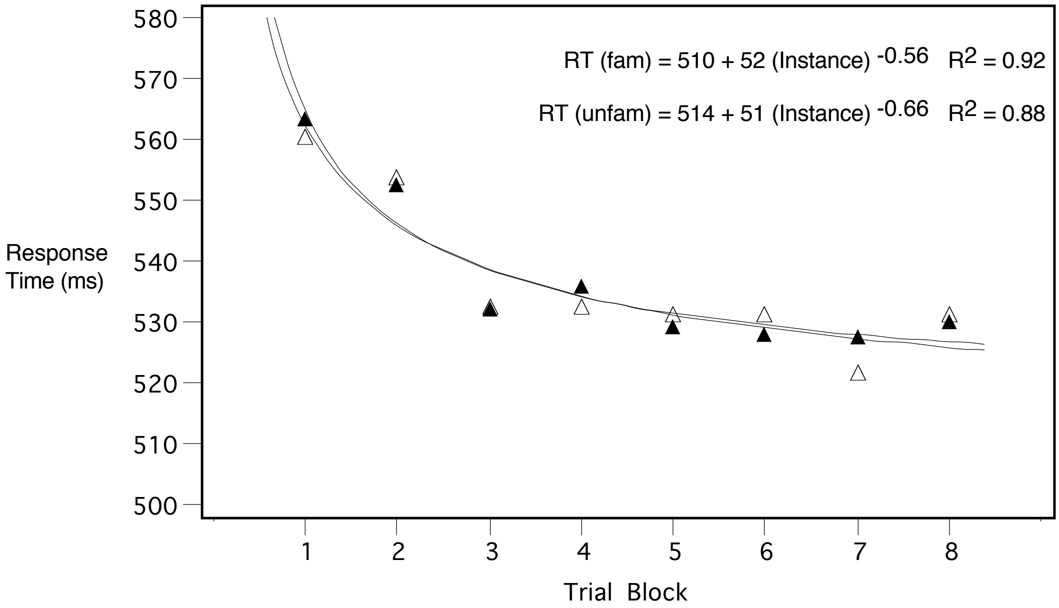
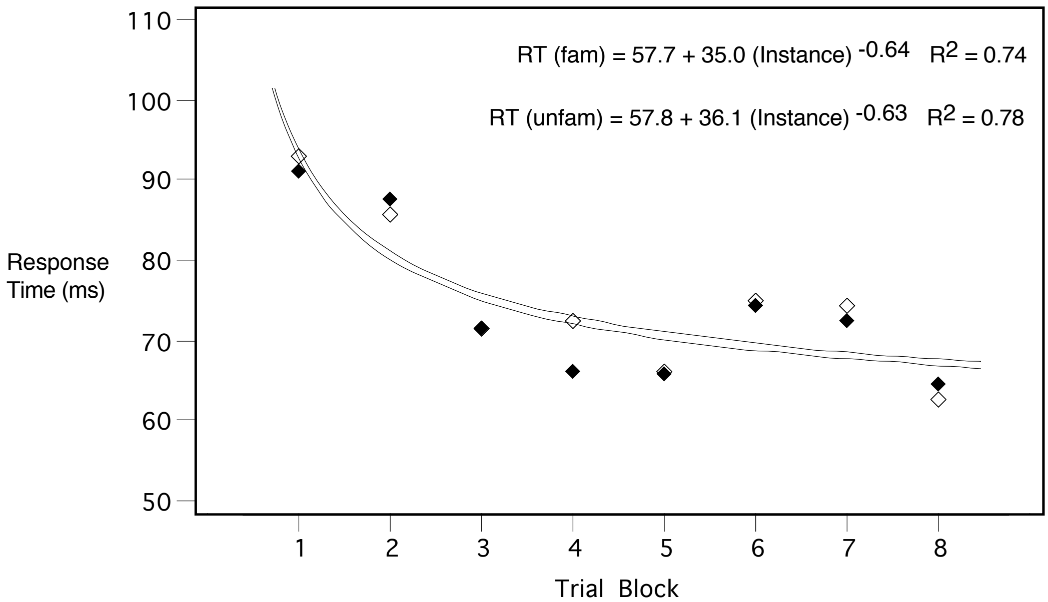


Figure 1 Power curves fitted to the means (upper) and the standard deviations of the correct response times.


RT (fam) = 510 + 52 (Instance) -0.56 R2 = 0.92
RT (unfam) = 514 + 51 (Instance) -0.66 R2 = 0.88
Response Time (ms)
580
570
560
550
540
530
520
510
500
1
2
3
4
5
6
7
8
Trial Block


RT (fam) = 57.7 + 35.0 (Instance) -0.64 R2 = 0.74
RT (unfam) = 57.8 + 36.1 (Instance) -0.63 R2 = 0.78
Response Time (ms)
110
100
90
80
70
60
50
1
2
3
4
5
6
7
8
Trial Block