Journal of Experimental Psychology: General
2012, Vol. 141, No. 1, 37–42

© 2011 American Psychological Association
0096-3445/11/$12.00 DOI: 10.1037/a0024236

BRIEF REPORT

Chess Masters Show a Hallmark of Face Processing With Chess

Amy L. Boggan and James C. Bartlett
The University of Texas at Dallas

Daniel C. Krawczyk
The University of Texas at Dallas and University of Texas
Southwestern Medical Center

Face processing has several distinctive hallmarks that researchers have attributed either to face-specific mechanisms or to extensive experience distinguishing faces. Here, we examined the face-processing hallmark of selective attention failure—as indexed by the congruency effect in the composite paradigm—in a domain of extreme expertise: chess. Among 27 experts, we found that the congruency effect was equally strong with chessboards and faces. Further, comparing these experts with recreational players and novices, we observed a trade-off: Chess expertise was positively related to the congruency effect with chess yet negatively related to the congruency effect with faces. These and other findings reveal a case of expertise-dependent, facelike processing of objects of expertise and suggest that face and expert-chess recognition share common processes.

Keywords: face recognition, perception, expertise, chess

Supplemental materials: http://dx.doi.org/10.1037/a0024236.supp

Face processing has several distinctive hallmarks not found with other objects. These hallmarks include a strong, deleterious effect of inverted (vs. upright) presentation in perception and memory tasks (Bartlett & Searcy, 1993; McKone & Robbins, 2011; Murray, Yong, & Rhodes, 2000; Yin, 1969), high sensitivity to changes in spatial configuration in same–different and similarity-rating tasks (Barton, Keenan, & Bass, 2001; Searcy & Bartlett, 1996), impaired recognition of individual parts when other parts have been changed or removed (Tanaka & Farah, 1993; Tanaka & Sengco, 1997), and failures of selective attention to one part of a face (Bruce & Humphreys, 1994; Young, Hellawell, & Hay, 1987).

Some theorists have argued that these hallmarks—or some of them at least—reflect the operations of a specialized face module (McKone, Kanwisher, & Duchaine, 2007; McKone & Robbins, 2011). Others have proposed that these hallmarks reflect our great experience distinguishing or "individuating" faces (Diamond & Carey, 1986; Gauthier & Bukach, 2007; Gauthier, Curran, Curby, & Collins, 2003; Wong, Palmeri, & Gauthier, 2009). Although often viewed as a debate, this situation can also be viewed as a call for research on which key face processing aspects reflect domain-specific processes and which are due to our extensive face experience. Conclusively distinguishing domain-specific from experience-based hallmarks will be an important theoretical achievement and may advance techniques to improve face recognition in forensic contexts.

Here we employ the *composite paradigm* (Young et al., 1987), which produces the hallmark of *selective attention failures* in face recognition. Our point of departure was a study by Gauthier et al. (2003), who employed the composite paradigm with faces and cars using observers with varying car expertise. Participants viewed interleaved car composites and face composites, each with a clearly demarcated top and bottom half, and judged whether each item's *lower* half matched the preceding same-class item's lower half. The to-be-attended lower half could either match or mismatch the preceding same-class item's lower half, and the to-be-ignored upper half could either match or mismatch as well. If observers were selectively attending to the lower halves of items, performance should not have varied between congruent trials (in which either both halves matched or both halves mismatched) and incongruent trials (in which one half matched and the other did not). In fact, performance was higher on congruent trials with both faces and cars. Further, as car expertise increased, the congruency effect grew relatively stronger for faces interleaved with transformed cars than for faces interleaved with normal cars. These findings, along with converging electrophysiological data, were interpreted as evidence that the congruency effect reflects "holistic" processing and that as car expertise increases, holistic processing of normal cars increases and comes to interfere with holistic processing of faces.

Recent studies have buttressed the conclusion that as expertise increases in an object domain, there is increased interference between processing these objects and processing faces (McKeeff, McGugin, Tong, & Gauthier, 2010; McGugin, McKeeff, Tong &

Amy L. Boggan and James C. Bartlett, School of Behavioral and Brain Sciences, The University of Texas at Dallas; Daniel C. Krawczyk, School of Behavioral and Brain Sciences, The University of Texas at Dallas, and Department of Psychiatry, University of Texas Southwestern Medical Center, Dallas, Texas.

We thank The University of Texas at Dallas Chess Program and Chess Team, The University of Texas at Dallas Chess Program Director James Stallings, Karina Vazirova, Rachel Wyatt Zabierek, and Anjali Krishnan for their assistance. We also thank Mary Peterson, Fernand Gobet, and Jessica Taubert for their comments on the article and Bradley Duchaine for the Cambridge Face Memory Test.

Correspondence concerning this article should be addressed to Amy L. Boggan, School of Behavioral and Brain Sciences, The University of Texas at Dallas, 800 West Campbell Road, GR 4.1, Richardson, TX 75080. E-mail: aboggan@utdallas.edu

Gauthier, 2011). However, more research is needed on whether this common process pertains to selective attention failures as measured by the congruency effect. A concern is that the congruency effect in Gauthier et al. (2003) was much larger for faces than for cars, and the effect found with cars differed only slightly between car experts and novices. Indeed, facelike processing effects with nonfacial objects of expertise often have been small or not significant (Robbins & McKone, 2007; but see Curby, Glazek, & Gauthier, 2009), leading some to question whether facelike processing truly has occurred (McKone et al., 2007). A counterargument holds that small effects are consistent with an expertise account as the experts in prior studies have much less experience with the nonfacial objects than people have with faces (Gauthier & Bukach, 2007). Further, if the Gauthier et al. (2003) interleaved procedure produces interference between the holistic processing of faces and cars, this procedure might underestimate the congruency effect with cars.

These points notwithstanding, it is important to test a strong prediction of an expertise account: The congruency effect with nonfacial objects should be highly robust—perhaps as robust as the effect with faces—among persons with sufficiently high expertise. This prediction holds even in conditions of interference, as underestimations of congruency effects should be as large with faces as with objects, given sufficient object-expertise. Indeed, in conditions of interference, another prediction can be made: Compared to novices, chess experts should show not only a *stronger* congruency effect with objects of expertise, but also a relatively *weak* congruency effect with faces.

To test these predictions, we performed an experiment similar to Gauthier et al. (2003), using chessboards (rather than cars) and chess experts, recreational players, and chess novices. We chose chess for several reasons: First, chess skill can be extremely high, is based on thousands of hours of practice (Gobet & Campitelli, 2007), and is quantifiable by reliable and valid measures such as Elo ratings (Elo, 1986; Ericsson & Smith, 2011). Second, true chess novices are available, an important consideration since the "nonexperts" in many prior studies doubtlessly had some skill. Third, chess experts study and remember precise positions from specific games (e.g., "the Immortal Game"), and such *individuating* experience is considered critical for facelike processing (Tarr & Gauthier, 2000; Wong et al., 2009). Fourth, chess displays are physically quite different from faces, so facelike processing of chessboards cannot be attributed to their facelike appearance.

Finally, we hoped to close a gap between prior research on expertise and research on face processing. Chessboard processing is regarded as the drosophila of expertise effects. Chess masters possess a substantial memory advantage for game positions over less-skilled players (Chase & Simon, 1973), and evidence suggests that this advantage is attained through extensive, effortful practice (Campitelli & Gobet, 2008). Chess skill does not seem to run in families (Charness, 1992; Cranberg & Albert, 1988), and hours-of-practice is a stronger predictor of chess ability than other factors (Bilalić, McLeod, & Gobet, 2007). Thus, chess, a domain in which skill is strongly linked to experience, provides an ideal comparison with domains such as faces, in which experience effects are less well understood.

In summary, we investigated whether extreme chess expertise would be associated with a facelike congruency effect with chessboard displays. Additionally, we examined whether the interleaved paradigm would reveal a trade-off pattern, such that chess expertise was *positively* related to the congruency effect with chess yet *negatively* related to the congruency effect with faces.

Method

Participants

Participants included 27 chess experts, 22 recreational players, and 20 chess novices (M age = 21.9 years, 24.6 years, and 23.1 years, respectively) from The University of Texas at Dallas. Experts belonged to the university chess team and/or chess club, and a donation was made in consideration of their participation. United States Chess Federation Elo ratings ranged from 1,866 (Class A player) to 2,629 (Grandmaster) and averaged 2,258 (Master level), 3 standard deviations above an average tournament player. Recreational players and novices participated for course credit and differed in their self-reports of playing chess ("regularly" for players versus "not at all" for novices). All participants gave written informed consent, and the institutional review board approved the study.

Stimuli

Neutral-expression male faces from the Psychological Image Collection at Stirling (http://pics.psych.stir.ac.uk/) were divided into top and bottom halves across the nose and paired with different, random faces to form composites. The chess stimuli were early positions (26–32 pieces on the board, M = 30) from tournament games. The 144 faces and 144 games were displayed as 256 pixels × 256 pixels, 9 cm × 9 cm grayscale images divided by a horizontal red line.

Design and Procedure

Participants completed a dual-task interleaved paradigm (see Gauthier et al., 2003). They viewed interleaved faces and chessboards and were instructed to judge whether the bottom half of a chessboard or face matched the bottom half of the previous chessboard or face (see Figure 1), ignoring the top halves. Each stimulus was displayed until the participant indicated a same–different decision by key press, with an upper limit of 3,500 ms.

The design included a between-group expertise variable (novices, recreational players, experts) and within-group stimulus class (chessboard, face) and congruency (congruent, incongruent) variables. On congruent trials, the top and bottom halves were either both the same as or both different from the preceding same-class stimulus. On incongruent trials, the top half was the same and the bottom was different, or vice versa. This *full design* allows assessment of discrimination accuracy (d'), independent of criterion, for both congruent and incongruent trials (see Richler, Cheung & Gauthier, 2011).

Both the top and the bottom half of each chess display were taken from positions within the same game. In all trials analyzed, the top and bottom parts of the board were either unchanged from the prior chess stimulus or involved a change in piece location only (i.e., the number of pieces remained constant with no pieces "captured"). Because chess displays were early game positions, it was necessary to switch from one game to another after runs of

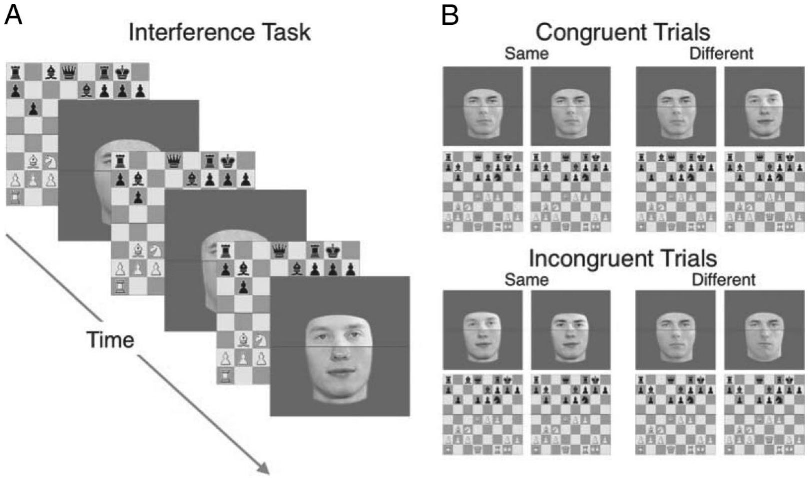

Figure 1. A: Continuous two-back interference paradigm adapted from Gauthier et al. (2003). Participants were instructed to attend to the bottom half of each display and indicate by key press whether the bottom half of the current stimulus was the same as or different from the most recent, same-category stimulus. B: Sample stimuli in the complete composite paradigm. For congruent trials, both the top and bottom halves either stayed the same or changed. For incongruent trials, either the top changed or the bottom changed. The faces are cropped images from *The Psychological Image Collection at Stirling*, by the University of Stirling Psychology Department, n.d., Stirling, Scotland: University of Stirling Psychology Department. Copyright by the University of Stirling Psychology Department. Adapted with permission.

3–7 ($M = 4.4$) displays, resulting in occasional trials (11%) in which both halves of a chessboard display were quite different from the preceding display. These different-game trials rarely produced false alarms and were not analyzed further.[1]

After the chess/face task, participants completed a chess experience questionnaire. They then completed the Cambridge Face Memory Test (CFMT; Duchaine & Nakayama, 2006), a standardized face-recognition assessment.

Results

We computed d's based on hits for bottom-same trials and false alarms for bottom-different trials, separately for congruent and incongruent conditions. We used an analysis of variance (ANOVA) to examine the between-group expertise variable (experts, recreational players, novices) and within-group stimulus (chess, face) and congruency (congruent, incongruent) variables. There were strong main effects of expertise, $F(2, 66) = 8.47$, $p = .001$, $\eta^2 = .065$, stimulus, $F(1, 66) = 130.3$, $p < .001$, $\eta^2 = .149$, and congruency, $F(1, 66) = 122.1$, $p < .001$, $\eta^2 = .176$. These were qualified by Expertise × Stimulus, $F(2, 66) = 5.062$, $p < .01$, $\eta^2 = .012$, Expertise × Congruency, $F(2, 66) = 18.86$, $p < .001$, $\eta^2 = .054$, and Stimulus × Congruency interactions, $F(1, 66) = 38.68$, $p < .001$, $\eta^2 = .035$, as well as the Expertise × Stimulus × Congruency Interaction, $F(2, 66) = 13.8$, $p < .001$, $\eta^2 = .025$. Lower d's on incongruent trials than on congruent trials reflect selective attention failures to task-relevant (bottom) stimuli halves, a face processing hallmark. As shown in Figure 2A, the congruency effect with faces occurred in all three groups, but only chess experts showed an equally strong congruency effect with chessboards.[2]

Average scores on the CFMT rose from the experts (53.3 of 72; $SD = 10.8$), to the players (56.5; $SD = 8.8$), to the novices (61.0; $SD = 6.7$), $F(2, 66) = 3.99$, $p = .02$, $\eta^2 = .108$. However, the Expertise × Stimulus × Congruency interaction in the chess/face task remained highly significant with CFMT scores included as a covariate.

If the congruency effect with faces and chessboards reflects a common process that is subject to interference, chess experts should show not only a *stronger* congruency effect with chess but also a *weaker* congruency effect with faces than less-skilled observers. This pattern is illustrated in Figure 2B, which shows the congruency effect for faces (left) and chess (middle).

The congruency effect with chess was strongest among experts, whereas the congruency effect with faces was strongest among novices. Further, the *differential* congruency effect (i.e., the face congruency effect minus that for chess; see Figure 2B, right) rose steadily from experts ($M = -0.03$) to recreational players ($M = 0.69$) to novices ($M = 1.35$), $F(2, 66) = 13.80$, $p < .001$, $\eta^2 = .295$, with significant group differences (Tukey's Honestly Significant Difference test, $p < .05$).

To further characterize the relations between experts' processing of faces and chessboards, we computed correlations among Elo ratings and face and chessboard recognition *within* the expert group. Although Elo ratings were not reliably correlated with the recognition measures (all rs $< |.19|$), experts' d's with faces and chessboards were strongly correlated on congruent trials, $r(27) = +.81$, $p < .001$, CI

---

[1] Additional "same" face trials were used to preserve the balance of same and different trials overall. To manipulate the difficulty of chessboard processing by experts, we reversed the chessboard displays about the middle, vertical axis (Gobet & Simon, 1996) in half of the trial blocks (see the supplemental materials).

[2] A criterion score (C) analysis did not support the interactions found with d's.

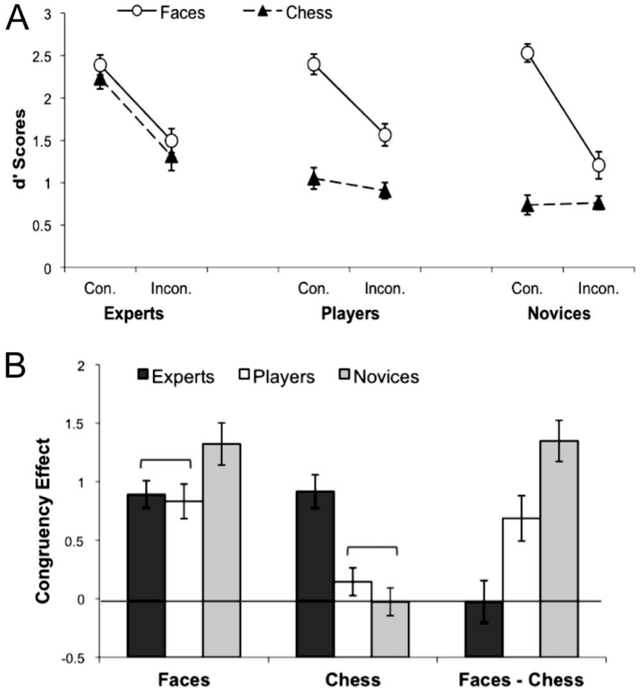

Figure 2. A: Mean d' for congruent (Con.) and incongruent (Incon.) trials, by group. The congruency effect was reliable in all three groups for faces and among chess experts for chess. B: Congruency effect (congruent-incongruent difference) for faces and chess, by group. Novices showed stronger congruency for faces (left), whereas experts showed stronger congruency for chessboards (middle). The face–chess difference in congruency was inversely related to chess expertise (right). Error bars show standard errors of the mean. Within each set of three bars, those not under a common bracket differed by t test ($p < .05$).

[.621, .910] but not on incongruent trials, $r = +.27$, $p = .17$, CI [$-.123$, .590] (see Figure 3). We believe that expert individuals differ in a process that generally increases encoding and/or retention of faces and chessboards but causes selective attention failures that attenuate its positive effects on incongruent trials.

We also examined experts' reports of weekly hours spent playing/studying chess (range: 2.8–51.8) and chess starting age (3–16 years). Being highly skewed, these measures were transformed with a natural log to compute correlations with our face- and chess-processing measures. The practice estimates showed no reliable correlations, but starting age was reliably correlated with the face congruency effect, $r(27) = .42$, $p = .03$, CI [.048, .689], though not with the chess congruency effect, $r = -.06$, CI [$-.43$, .327]. Thus, an early starting age for chess was associated with a reduced face congruency effect (see Figure 4). This finding suggests that processes underlying the congruency effect may be subject to minor disruption from intensive early experience with chess, though in the future, researchers must address the role of a possible third variable linked to personality or social-emotional processes.

Discussion

In identifying the congruency effect among experts in a nonface domain, our findings indicate that this face processing hallmark reflects our high expertise with faces as opposed to domain-specific factors. There are other face-processing hallmarks that may or may not emerge through experience (see Robbins & McKone, 2007, and Curby et al., 2009, for data on facial inversion effects). Further, several studies report genetic links to face recognition ability (Duchaine, Germine, & Nakayama 2007; Zhu et al., 2010), and research with infants suggests that some face-processing hallmarks may emerge with significantly less experience than chess expertise requires (McKone, Crookes, & Kanwisher, 2009). Additionally, early experience can determine whether typical face processing will ever emerge, as individuals born with cataracts (vision-deprived for several months) process faces less holistically than do those born unaffected (Le Grand, Mondloch, Maurer, & Brent, 2004). For these reasons, in the future, researchers will continue to address the domain-specific and experiential factors underlying the special qualities of face processing. The present study demonstrates that experience can support one of these qualities, selective attention failures in the composite paradigm.

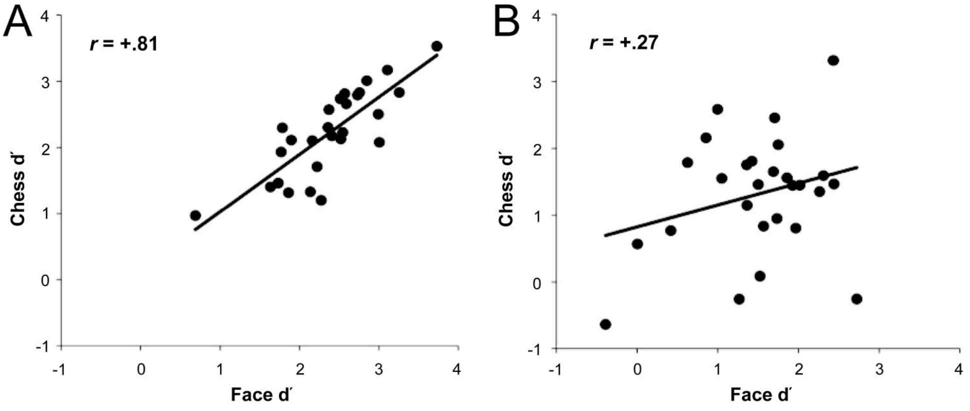

Figure 3. Face recognition by chess game recognition among experts. Chess discrimination was strongly correlated ($p < .001$) with face discrimination in the congruent condition (A) but not in the incongruent condition (B).

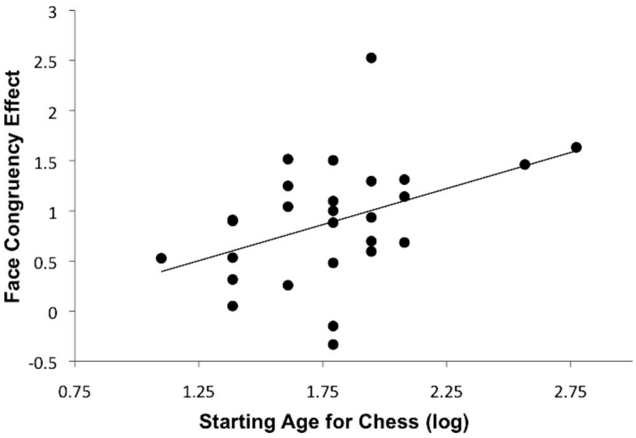

Figure 4. Face congruency effect for experts by log age of starting chess. An early starting age for chess is associated with a decrease in the facial congruency effect, $r(27) = .42$, $p = .03$.

The present study also adds to prior evidence that at high experience levels, face and object recognition share a common process. The association between chess expertise and the differential congruency effect with faces versus chess (Figure 2b) supports a common-process view, buttressed by the robust correlation between face and chessboard memory on congruent trials (Figure 3A). The latter finding is especially persuasive, as the face–chess correlation does *not* generalize to incongruent trials (Figure 3B) and, therefore, is not easily attributable to motivational or general ability factors. Rather, the findings point to a process that can be employed with face as well as chess stimuli and that also is subject to individual differences, within an expert group.

The nature of this common process requires more research. Yovel and Kanwisher (2008) examined correlations between memory for face feature *spacing* and memory for face feature *shapes*. They found strong positive correlations with upright faces, though not with inverted faces or houses, regardless of orientation. These observations suggest that upright face recognition involves a type of holistic processing in which feature-spacing information and feature-shape information are tightly integrated (Tanaka & Farah, 1993; Tanaka & Sengco, 1997). A key question is whether experts' chessboard recognition involves similar holistic processing of shape (distinguishing kings, queens, etc.) and spacing (board positions).

Several considerations suggest that it does. The congruency effect is thought to measure holistic processing (Curby & Rossion, 2010; Gauthier, Klaiman, & Schultz, 2009; Hsiao & Cottrell, 2009; but see McKone, 2010) and, according to de Groot (1978), "the integration of the [chess] position . . . consists essentially of taking stock of the spatial, functional, and dynamic relations among the perceived parts—so that they can be combined into one whole" (p. 333). Supporting de Groot's holistic hypothesis, experts require fewer eye fixations to encode positions and tend to focus between, rather than on, individual pieces (de Groot & Gobet, 1996; Reingold & Charness, 2005). Further, the chess cognition literature (see Gobet & Charness, 2006) offers overwhelming evidence that experts encode chess configurations as unitary chunks or larger "templates" containing up to 15 pieces, with chunk size increasing with expertise (Gobet & Clarkson, 2004, and see Gobet & Chassy, 2009, for computer simulations). Whether several chess pieces form a meaningful chunk depends both on the particular pieces and on their spacing on the board (see Saariluoma, 1984). Hence, a chunking and template-formation process involving integrated part-shape and part-spacing information is a strong candidate for what is common in face and chessboard processing among chess experts.

A final observation concerns the positive relationship between the facial congruency effect and age of starting chess (Figure 4). The correlation suggests that early chess exposure might be linked to subtle but theoretically important effects on face processing; this possibility is worth testing further.

References

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology, 25,* 281–316. doi:10.1006/cogp.1993.1007

Barton, J. Keenan, J., & Bass, T. (2001). Discrimination of spatial relations and features in faces: Effects of inversion and viewing duration. *British Journal of Psychology, 92,* 527–549. doi:10.1348/000712601162329

Bilalić, M., McLeod, P., & Gobet, F. (2007). Does chess need intelligence? A study with young chess players. *Intelligence, 35,* 457–470. doi:10.1016/j.intell.2006.09.005

Bruce, V., & Humphreys, G. (1994). Recognizing objects and faces. *Visual Cognition, 1,* 141–180. doi:10.1080/13506289408402299

Campitelli, G., & Gobet, F. (2008). The role of practice in chess: A longitudinal study. *Learning and Individual Differences, 18,* 446–458. doi:10.1016/j.lindif.2007.11.006

Charness, N. (1992). The impact of chess research on cognitive science. *Psychological Research, 54,* 4–9. doi:10.1007/BF01359217

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4,* 55–81. doi:10.1016/0010-0285(73)90004-2

Cranberg, L. D., & Albert, M. L. (1988). The chess mind. In L. K. Obler & D. Fein (Eds.), *The exceptional brain: Neuropsychology of talent and special abilities* (pp. 156–190). New York, NY: Guilford Press.

Curby, K. M., Glazek, K., & Gauthier, I. (2009). A visual short-term memory advantage for objects of expertise. *Journal of Experimental Psychology: Human Perception and Performance, 35,* 94–107. doi:10.1037/0096-1523.35.1.94

Curby, K. M., & Rossion, B. (2010). Competition between face and nonface domains of expertise. In I. Gauthier, M. Tarr, & D. Bub (Eds.), *Perceptual expertise: Bridging brain and behavior* (pp. 245–270). New York, NY: Oxford University Press.

de Groot, A. D. (1978). *Thought and choice in chess.* The Hague, the Netherlands: Mauton.

de Groot, A. D., & Gobet, F. (1996). *Perception and memory in chess: Heuristics of the professional eye.* Assen, the Netherlands: Van Gorcum.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General, 115,* 107–117. doi:10.1037/0096-3445.115.2.107

Duchaine, B., Germine, L., & Nakayama, K. (2007). Family resemblance: Ten family members with prosopagnosia and within-class object agnosia. *Cognitive Neuropsychology, 24,* 419–430. doi:10.1080/02643290701380491

Duchaine, B., & Nakayama, K. (2006). The Cambridge face memory test: Results for neurologically intact individuals and an investigation of its validity using inverted face stimuli and prosopagnosic participants. *Neuropsychologia, 44,* 576–585. doi:10.1016/j.neuropsychologia.2005.07.001

Elo, A. E. (1986). *The rating of chess players, past and present* (2nd ed.). New York, NY: Arco Chess.

Ericsson, K. A., & Smith, J. (2011). Prospects and limits of the empirical study of expertise: An introduction. In D. J. Levitin (Ed.), *Foundations of cognitive psychology* (pp. 393–424). Boston, MA: Allyn & Bacon.

Gauthier, I., & Bukach, C. (2007). Should we reject the expertise hypothesis? *Cognition, 103,* 322–330. doi:10.1016/j.cognition.2006.05.003

Gauthier, I., Curran, T., Curby, K., & Collins, D. (2003). Perceptual interference supports a non-modular account of face processing. *Nature Neuroscience, 6,* 428–432. doi:10.1038/nn1029

Gauthier, I., Klaiman, C., & Schultz, R. (2009). Face composite effects reveal abnormal face processing in autism spectrum disorders. *Vision Research, 49,* 470–478. doi:10.1016/j.visres.2008.12.007

Gobet, F., & Campitelli, G. (2007). The role of domain-specific practice, handedness, and starting age in chess. *Developmental Psychology, 43,* 159–172. doi:10.1037/0012-1649.43.1.159

Gobet, F., & Charness, N. (2006). Expertise in chess. In K. A. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 523–538). New York, NY: Cambridge University Press.

Gobet, F., & Chassy, P. (2009). Expertise and intuition: A tale of three theories. *Minds & Machines, 19,* 151–180. doi:10.1007/s11023-008-9131-5

Gobet, F., & Clarkson, G. (2004). Chunks in expert memory: Evidence for the magical number four. Or is it two? *Memory, 12,* 732–747. doi:10.1080/09658210344000530

Gobet, F., & Simon, H. (1996). Recall of random and distorted chess positions: Implications for the theory of expertise. *Memory & Cognition, 24,* 493–503. doi:10.3758/BF03200937

Hsiao, J., & Cottrell, G. (2009). Not all visual expertise is holistic, but it may be leftist. *Psychological Science, 20,* 455–463. doi:10.1111/j.1467-9280.2009.02315.x

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2004). Impairment in holistic face processing following early visual deprivation. *Psychological Science, 15,* 762–768. doi:10.1111/j.0956-7976.2004.00753.x

McGugin, R. W., McKeeff, T. J., Tong, F., & Gauthier, I. (2011). Irrelevant objects of expertise compete with faces during visual search. *Attention, Performance & Psychophysics, 73,* 309–317.

McKeeff, T. J., McGugin, R. W., Tong, F., & Gauthier, I. (2010). Expertise increases the functional overlap between face and object perception. *Cognition, 117,* 355–360. doi:10.1016/j.cognition.2010.09.002

McKone, E. (2010). Face and object recognition: How do they differ? In V. Coltheart (Ed.), *Tutorials in visual cognition* (pp. 261–303). London, England: Psychology Press.

McKone, E., Crookes, K., & Kanwisher, N. (2009). The cognitive and neural development of face recognition in humans. In M. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 467–482). Cambridge, MA: The MIT Press.

McKone, E., Kanwisher, N., & Duchaine, B. (2007). Can generic expertise explain special processing for faces? *Trends in Cognitive Sciences, 11,* 8–15. doi:10.1016/j.tics.2006.11.002

McKone, E., & Robbins, R. (2011). Are faces special? In A. Calder, G. Rhodes, J. Haxby, & M. Johnson (Eds.), *Oxford handbook of face perception* (pp. 149–176). New York, NY: Oxford University Press.

Murray, J., Yong, E., & Rhodes, G. (2000). Revisiting the perception of upside-down faces. *Psychological Science, 11,* 492–496. doi:10.1111/1467-9280.00294

Reingold, E. M., & Charness, N. (2005). Perception in chess: Evidence from eye movements. In G. Underwood (Ed.), *Cognitive processes in eye guidance* (pp. 325–353). Oxford, England: Oxford University Press.

Richler, J. J., Cheung, O. S., & Gauthier, I. (2011). Holistic processing predicts face recognition. *Psychological Science, 22,* 464–471. doi:10.1177/0956797611401753

Robbins, R., & McKone, E. (2007). No face-like processing for objects-of-expertise in three behavioural tasks. *Cognition, 103,* 34–79. doi:10.1016/j.cognition.2006.02.008

Saariluoma, P. (1984). *Coding problem spaces in chess: A psychological study.* Turku, Finland: Societas Scientiarum Fennica.

Searcy, J. H., & Bartlett, J. C. (1996). Inversion and processing of component and spatial-relational information in faces. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 904–915. doi:10.1037/0096-1523.22.4.904

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

Tanaka, J. W., & Sengco, J. A. (1997). Features and their configuration in face recognition. *Memory & Cognition, 25,* 583–592. doi:10.3758/BF03211301

Tarr, M. J., & Gauthier, I. (2000). FFA: A flexible fusiform area for subordinate-level visual processing automatized by expertise. *Nature Neuroscience, 3,* 764–769. doi:10.1038/77666

University of Stirling Psychology Department. (n.d.). PICS database: The psychological image collection at Stirling. Stirling, Scotland: University of Stirling Psychology Department. Retrieved from http://pics.psych.stir.ac.uk/

Wong, A., Palmeri, T., & Gauthier, I. (2009). Conditions for facelike expertise with objects: Becoming a Ziggerin expert—But which type? *Psychological Science, 20,* 1108–1117. doi:10.1111/j.1467-9280.2009.02430.x

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology, 81,* 141–145. doi:10.1037/h0027474

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configurational information in face perception. *Perception, 16,* 747–759. doi:10.1068/p160747

Yovel, G., & Kanwisher, N. (2008). The representations of spacing and part-based information are associated for upright faces but dissociated for objects: Evidence from individual differences. *Psychonomic Bulletin & Review, 15,* 933–939. doi:10.3758/PBR.15.5.933

Zhu, Q., Song, Y., Hu, S., Li, X., Tian, M., Zhen, Z., . . . Liu, J. (2010). Heritability of the specific cognitive ability of face perception. *Current Biology, 20,* 137–143. doi:10.1016/j.cub.2009.11.067

Received February 11, 2011
Revision received April 29, 2011
Accepted May 1, 2011 ■