Here's Looking at You: Visual Similarity Exacerbates the Moses Illusion for Semantically Similar Celebrities

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Abstract

When people read questions like *How many animals of each kind did Moses take on the ark?*, many mistakenly answer "two" despite knowing that Noah sailed the ark. This "Moses illusion" occurs when names share semantic features. Two experiments examined whether shared *visual* concepts (facial features) exacerbate Moses illusions for celebrity names. Questions contained an unrelated distractor name or a semantic distractor name that was visually similar or dissimilar to the correct target name. Both experiments revealed more Moses illusions occurred for questions containing a visually similar semantic distractor compared to either visually dissimilar or unrelated distractors. Furthermore, presenting a picture of the target (Experiment 1) or the visually similar distractor (Experiment 2) before the question increased accurate detection of the illusion, independent of distractor type. Results challenge theoretical explanations of the Moses illusion as resulting from purely shallow semantic processing and demonstrate the importance of visual information in processing proper names, even when presented in written form.

Keywords: name recognition, facial features, Moses Illusion, reading, language

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Proper names are particularly difficult to learn and remember compared to other types of words or biographical information (Barresi, Obler, & Goodglass, 1998; Fraas et al., 2002; James, 2004; Stanhope & Cohen, 1993; Young, Hay, & Ellis, 1985). Most research has focused on names' decreased *retrieval* (i.e., fewer successful retrievals and more tip-of-the-tongue states; e.g., Burke, MacKay, Worthley, & Wade, 1991; Hanley & Chapman, 2008), as it is considerably easier to *recognize* names (e.g., Peressotti, Cubelli, & Job, 2003). However, under some circumstances, name recognition during comprehension can become more difficult. One example is the Moses illusion, a recognition error that occurs in response to questions like *How many animals of each kind did Moses take on the ark?* Many people answer “two”, only realizing their failure to catch the mistake after being reminded that Noah, not Moses, took animals on the ark (e.g., Erickson & Mattson, 1981). Moses illusions have been proposed to result from shallow semantic processing of the question’s meaning, where not every word's meaning is thoroughly checked for congruity (e.g., Erickson & Mattson, 1981; Kamas, Reder, & Ayers, 1996; Reder & Kusbit, 1991; Song & Schwarz, 2008). Consequently, a distractor name similar to the meaning of the question (e.g., a biblical figure, *Moses*) is less easily detected as anomalous than a dissimilar name (e.g., *Nixon*). Furthermore, more illusions occur when the distractor and target names have high semantic overlap (e.g., *Moses* and *Noah*) compared to low (e.g., *Adam* and *Noah*; van Jaarsveld, Dijkstra, & Hermans, 1997; van Oostendorp & de Mul, 1990). However, people can share not only semantic information (e.g., both *Al Gore* and *Joe Biden* are politicians, were vice presidents, etc.), but also visual features (e.g., both are older males and have graying hair), the latter of which are critical for recognizing and distinguishing people. This experiment explored whether visual concepts, specifically facial features, play a significant role in inducing the Moses illusion.

Support for non-semantic influences on the Moses illusion comes from Shafto and MacKay (2000, 2010). Shafto and MacKay (2000) demonstrated that phonological overlap could induce the illusion independently from semantics, as more illusions occurred when replacing the name *Neil Armstrong* (astronaut) with *Louis Armstrong* (musician) compared to *Dizzy Gillespie* (musician), even though *Louis Armstrong* and *Dizzy Gillespie* were equally semantically distinct from *Neil Armstrong*. Although this finding can be challenged because both *Neil* and *Louis* shared a lexical-surname node (meaning that *Armstrong* was still semantically compatible with the sentence), they demonstrated additional evidence in support of phonological influences by showing greater susceptibility to the illusion when semantic distractors were also phonologically related to targets (e.g., *Lyndon Johnson* and *Andrew Johnson*). Shafto and MacKay (2010) also showed a pure phonological effect using lexically-distinct homophones, i.e., more illusions occurred when *mail* replaced *male* in a sentence compared to *mill* or *shed*. These results were problematic for a purely semantic explanation of the Moses illusion, and they instead proposed an account within Node Structure Theory (NST), an interactive activation model of lexical access (e.g., MacKay, 1987), where names are represented in multilevel systems (see Figure 1). Consider the person *Brad Pitt*: Within NST, propositional nodes (biographical information; e.g., actor) and visual concept nodes (a holistic representation of what the person looks like, also connecting to visualizable propositions like "has blue eyes") independently connect to lexical nodes (the first name *Brad* and last name *Pitt*, as well as the proper name phrase *Brad Pitt*), which then connect to phonological nodes (the names' sounds).

Within NST, the Moses illusion occurs when the target (the correct agent of the sentence) receives a convergence of priming from multiple sources, resulting in its activation instead of the distractor. Consider the earlier example, where Moses is the distractor and Noah is the target. While the distractor's lexical node receives bottom-up priming when the written word "Moses" is perceived, the target's lexical node receives top-down priming via propositional nodes corresponding to information listed in the question as well as priming from the distractor via shared semantic links (e.g., both are biblical leaders). Thus, instead of activating the distractor (which would allow people to detect that the name did not fit the question context), the non-presented target receives the most priming, its lexical node becomes activated, and the distractor is miscomprehended as the correct name for that context, resulting in the illusion.

Experiment 1

Theoretical explanations where converging sources of priming cause the Moses illusion allow for the possibility of shared facial features between the target and distractor to exacerbate the illusion, as illustrated in Figure 2. In NST, facial features are housed in “visual concept nodes” that also connect to visualizable propositions. These nodes are connected to other propositional nodes at the semantic level as well as the lexical node (MacKay & Burke, 1991) and become activated when recognizing an image of the person or even discussing a person. Thus, visual information is accessed even when the task does not explicitly require identification of visual characteristics (e.g., while reading biographical information). To test the hypothesis that visual similarity is relevant for inducing the Moses illusion, Experiment 1 used celebrity names, as these are people whose facial features are familiar to college students. Specifically, we predicted that when a question contains a distractor (e.g., *Chris Hemsworth*) that is both semantically related and visually similar in terms of facial features shared with the target (e.g., *Brad Pitt*), the target receives additional priming from the shared connections between visual concept nodes, which should result in greater susceptibility to the illusion relative to a visually dissimilar semantic distractor (e.g., *Hugh Jackman*).

Furthermore, if visual similarity between a target and a distractor increases susceptibility to the Moses illusion, then highlighting visual *differences* between the target and the distractor should reduce susceptibility. Reder and Kusbit (1991; see also Kamas et al., 1996) observed that presenting relevant facts about the targets in text form (e.g., *Noah took two animals of each kind on the ark*) before reading invalid questions increased participants' awareness of anomalous distractors. In our experiment, the target face was briefly (200 ms) presented immediately prior to the question to activate its visual concept node. Because this node is unique to the target, its activation should enable people to more successfully recognize the incongruity between the information in the question and the distractor name, decreasing illusion errors. Whether presentation of the target face has the same effect as a function of the distractor's visual similarity was also explored.

A subsidiary aim of this experiment was to collect several speed measures that could potentially influence the accuracy of detecting the Moses illusion: (1) participants' response times for selecting answers to the general knowledge questions, and (2) question reading times. With respect to response times, various studies (Kamas et al., 1996; Reder & Cleeremans, 1990; Reder & Kusbit, 1991; van Jaarsveld et al., 1997; van Oostendorp and de Mul, 1990) have shown that failure to detect the Moses illusion was not a consequence of a speed-accuracy tradeoff, i.e., answering too quickly or dedicating insufficient time to choosing the correct answer. We similarly recorded response times so that if visually similar distractors were more susceptible to the Moses illusion, we could ensure that this finding was not a result of faster response times in responding to questions containing these distractors.

With respect to reading times, Reder and Kusbit (1991) used a "moving window" technique (Just, Carpenter, & Wooley, 1982) to present the question one word at a time so that the time from each key press to the next was recorded, permitting the authors to compare reading times for different words throughout the sentence. They found that participants read distractor names more slowly than other content words in the question and interpreted these results as demonstrating that the Moses illusion was not due to overlooking the distractor name or failing to adequately encode it. Using a similar design, we expanded on Reder and Kusbit's work by recording word-by-word reading times and calculating average reading times for words presented *after* the distractor name. Although reading times for the individual distractors are one indicator of participants' awareness of the distractor name, it is possible that the distractor name is not actually comprehended until after it has been read, when it is being integrated with the rest of the question. Specifically, we wanted to ensure that post-distractor reading times were not influencing the incidence of Moses illusions in some way, e.g., reading questions more quickly could result in inadequate encoding of the distractor and subsequently increase Moses illusions. If visually similar distractors produce more Moses illusions as predicted, then it is important to confirm that their post-distractor reading times were not faster than questions containing the other distractor types.

Method

Participants.

Fifty-four participants (*M* = 18.67, *SD* = 1.06; aged 18-26; 35 females) were recruited from general psychology courses at the University of Florida and received partial fulfillment of a course requirement for participation. Participants were English speakers with no known diagnosis of reading difficulties or dyslexia. To ensure sufficient power to detect Moses illusions, the number of participants was determined by reviewing previous Moses illusion studies and their effect sizes (e.g., Reder & Kusbit, 1991; Shafto & MacKay, 2000; van Oostendorp & de Mul, 1990). Our experiment tested slightly more participants than previous studies (which ranged from 20 to 48) to have an equal number of the versions necessary for counterbalancing (see below).

Materials.

Moses Illusion Task. The Moses illusion task consisted of 96 general knowledge questions about celebrities familiar to college students. In valid versions, the target name (e.g., *Brad Pitt*) was embedded into the question (e.g., *Which movie features Brad Pitt attempting to rob a casino?*). In invalid versions (i.e., questions without a valid answer), one of three distractor names replaced the target: (1) a visually similar semantic distractor (e.g., *Chris Hemsworth*), (2) a visually dissimilar semantic distractor (e.g., *Hugh Jackman),* or (3) an unrelated distractor that was neither visually nor semantically related to the target (e.g., *Rick Santorum*).Visual similarity was initially determined using websites that commented on celebrities' similarities (e.g., www.totallylookslike.com). Targets and distractors mentioned as visually similar were categorized as visually similar, while targets and distractors not named on these sites were categorized as visually dissimilar. Semantic relatedness was defined in terms of the targets' and distractors' occupation (e.g., White, Abrams, & Frame, 2013), consisting of actors, singers, athletes, politicians, TV personalities, and movie directors/producers. Both visually similar and visually dissimilar semantic distractors had the same occupation as their associated targets, while unrelated distractors were of different occupations. All distractors were the same gender and race as the target and were similar in age to the target. Filler questions that always had a valid answer were included so that there were an equal number of questions presented whose answers were valid and invalid, but fillers were not analyzed further.

Questions were followed by five multiple choice answers: the correct "target" answer for the valid version of the question (e.g., *Ocean's 11*), two answers semantically related to the target answer but were incorrect for the valid version (e.g., *Tower Heist*, *The Italian Job*), a “don’t know” option, and a “can't say” option. Participants were instructed to choose don’t know if they did not know the answer to the question and can't say if the question, when taken literally, could not be answered. The don’t know and can’t say responses were always presented as the fourth (d) and fifth (e) multiple choice options (respectively), while the order of the other multiple-choice responses was counterbalanced so that the target answer appeared in any one of the first three positions (a, b, or c) equally often across participants.

The questions were randomly presented and counterbalanced so that participants only received one question about a particular target. Of the 96 questions presented, 48 were invalid experimental questions (16 of each distractor type), 6 were valid versions of experimental questions, and 42 were fillers. Within each experimental version, half of the questions were preceded by a target picture, also counterbalanced across participants. Pictures were color images selected from Google images. Each picture was 4" x 4", consisting of a face that was not obstructed and clearly recognizable.

Pilot testing. Two initial pilot tests were conducted to verify college students' familiarity with our experimental targets and distractors and also the validity of our visual similarity and semantic similarity manipulations. In the first pilot test, 37 participants saw the written names of the distractors on a computer screen. They also saw half of the targets as written names and half as pictures to be used in the main experiment (counterbalanced across participants). They were asked to provide as much biographical information as possible about the individual, and the number of unique details given was used to assign a 1 (completely unfamiliar) to 5 (highly familiar) familiarity rating. Results indicated that whether presented as pictures (M = 3.8, SD = .6) or written names (M = 3.7, SD = .8), the 54 targets had overall mean familiarity scores that were considered familiar. Additionally, a 2 (similarity: visual, semantic) x 3 (distractor type: visually similar, visually dissimilar, unrelated) repeated-measures analysis of variance (ANOVA) by items for familiarity ratings was also conducted. A significant main effect of distractor type emerged, F (2, 159) = 3.96, MSE = .734, $\eta\rho^2$ = .047, p = .029, such that visually dissimilar distractors had higher familiarity scores than unrelated distractors (p = .006) and marginally higher scores than visually similar distractors (p = .084). Visually similar distractors did not differ from unrelated distractors (p = .296) (see Table 1).

A subsequent pilot test was conducted with a separate group of 34 participants to judge semantic and visual similarity between distractors and their associated targets. Participants saw two names appear side-by-side on a computer screen, one of which was a target name and the other of which was an associated distractor name; each target name was only presented once per participant, and target-distractor pairs were counterbalanced across participants. Participants were first instructed to rate how semantically similar the two individuals were, considering only biographical facts, using a 1 (completely unrelated) to 3 (strongly related) scale. After making this rating, participants were then asked to rate how visually similar the two individuals were using a 1 (not similar at all) to 3 (highly similar) scale but considering only facial features when making this judgment.

The 162 target-distractor pairs (54 visually similar, 54 visually dissimilar, 54 unrelated) were analyzed for semantic and visual similarity, as measured by participants' similarity ratings from the previously mentioned 1-3 Likert scales. A 2 (similarity: visual, semantic) x 3 (distractor type: visually similar, visually dissimilar, unrelated) repeated-measures ANOVA by items revealed a significant main effect of similarity, F (1,52) = 84.38, MSE =.068, $\eta\rho^2$ = .777, $p <$ .001, and a significant main effect of distractor type, F (2,104) = 180.71, MSE =.117, $\eta\rho^2$ = .619, $p < .001$, qualified by a significant two-way interaction between similarity and distractor type, F (2,104) = 64.86, MSE = .081, $\eta\rho^2$ = .555, $p <$. 001. Decomposing the interaction effect by looking within each level of similarity (see Table 1), pairwise comparisons indicated that for semantic similarity, visually similar and visually dissimilar distractors did not differ from one another (p = .202), but both were rated as more semantically similar to targets than unrelated distractors ($p < .001$). For visual similarity, pairwise comparisons indicated that visually similar distractors were rated as more visually similar to their associated targets than both visually dissimilar ($p < .001$) and unrelated ($p < .001$) distractors, which did not differ (p = .288).

Procedure

The task (see Figure 3) was presented via a computer program written in Visual Basic 5.0. Participants first received four practice trials, one of which was an invalid question (*Which type of tree did Abraham Lincoln supposedly deny chopping down?*). Following the practice trials, participants were alerted to the anomaly in the invalid question (*George Washington*, not *Abraham Lincoln*, chopped down a tree) and were reminded to choose can't say for questions like this. Participants saw a "+" to indicate that each trial was ready to begin. After pressing the enter key, a blank screen appeared for 100 ms, followed by a brief presentation (200 ms) of the target picture on half the trials or the first word of the general knowledge question in the center of the screen. Previous ERP studies have demonstrated that processes involved with face recognition begin as early as 160-170 ms after onset (e.g., Bentin, Allison, Puce, Perez, & McCarthy, 1996; Eimer, 2000). We used 200 ms to ensure sufficient time for fixating on the picture, as the presentation of a picture did not occur on every trial and therefore was not always expected. Participants were told that pictures sometimes appeared to test their ability to stay focused on the questions when distracted.

Participants pressed the spacebar to see the next word of the question, with previous words disappearing, until the last word of the question had been read. This method allowed for collection of reading times, a measure not often captured in Moses illusion studies (see Reder & Kusbit, 1991, for an exception). After each question, the multiple choice answers appeared for participants to press the chosen letter key (a, b, c, d, or e) as quickly as possible. If no keypress was made after six seconds, a message appeared, reminding participants to respond as quickly as possible. The entire session took approximately one hour.

Results

Individual cases were excluded from the analyses if participants took longer than six seconds to make a response and subsequently lost the opportunity to choose a multiple choice answer (timed out responses; 2.6% of cases). In addition, one question was excluded from analyses due to unintended semantic overlap between one of the distractor names and a non-target answer choice. Means and standard errors for selecting the various answer choices in response to invalid questions are shown in Table 2. Selecting the target answer (i.e., target illusions) indicates susceptibility to the Moses illusion, whereas selection of can't say indicates correct detection of the illusion for these types of questions. For brevity, all tables and figures report the means and standard errors from by-participant analyses, which were emphasized over the less powerful item analyses when effects between the two analyses conflicted. All pairwise comparisons were computed using Fischer's Least Significant Difference (LSD) calculations for significant main effects and interactions.

Target illusions. Table 2 illustrates that when participants selected an answer choice, it was almost always the target and not one of the other two non-target choices. A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture presence: picture not shown, picture shown) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on mean percent target illusions. Analyses illustrated a significant main effect of distractor type as shown in Figure 4, F_1 (2, 106) = 3.76, MSE_1 = .016, p_1 =. 026, $\eta\rho^2_1$ = .066, F_2 (2, 104) = 2.93, MSE_2 = .027, p_2 = .058, $\eta\rho^2_2$ = .053, where participants had more target illusions for questions containing visually similar distractors compared to those containing visually dissimilar distractors, p_1 = .017, p_2 = .083, or unrelated distractors, p_1 = .022, p_2 = .038. However, visually dissimilar and unrelated distractors did not differ, p_1 = .842, p_2 = .732. The main effect of picture presence was not significant, $F_1 < 1$, $F_2 < 1$, nor was the two-way interaction between distractor type and picture presence, $F_1 < 1$, $F_2 < 1$.

Can't say responses. Invalid questions were analyzed for participants' selection of the can't say option, the correct answer for these questions, from the possible answer choices. A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture presence: picture not shown, picture shown) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on the mean percentage of can’t say responses. Analyses indicated a significant main effect of distractor type, F_1 (2, 106) = 10.93, MSE_1 = .019, $p_1 < .001$, $\eta\rho^2_1$ = .171, F_2 (2, 104) = 4.88, MSE_2 = .042, p_2 = .009, $\eta\rho^2_2$ = .086, also shown in Figure 4. Pairwise comparisons revealed that both visually similar distractors and visually dissimilar distractors resulted in fewer can't say responses (i.e., greater illusion detection) than unrelated distractors, $p_1 < .001$, p_2 = .007, and p_1 = .040, p_2 = .131, respectively. However, questions containing visually similar distractors also resulted in fewer can't say responses than questions with visually dissimilar distractors (p_1 =

.012, p_2 = .082). Analyses also indicated a significant main effect of picture presence, F_1 (1, 53) = 11.39, MSE_1 = .073, p_1 = .001, $\eta\rho^2{}_1$ = .177, F_2 (1, 52) = 18.10, MSE_2 = .041, p_2 < .001, $\eta\rho^2{}_2$ = .258, where participants produced more can't say responses (i.e., had fewer illusions) when a question was preceded by a picture (M_1 = 57.1%, SE_1 = 3.6%) compared to when a question was not preceded by a picture (M_1 = 47.0%, SE_1 = 3.4%).The two-way interaction between distractor type and picture presence was not significant, F_1 < 1, F_2 < 1. Furthermore, the above results cannot be attributed to a lack of familiarity with targets and/or the facts asked about them in the questions: For valid versions of the experimental questions, participants correctly selected the target answer 86.8% of the time.

Response times. Response times (answer RTs, in ms) for participants' selection of the correct multiple-choice answer for invalid questions (i.e., can't say) were analyzed. To identify outliers, overall means for participants and items were calculated for answer RTs across conditions, and RTs exceeding 2 *SD*s from the mean were excluded from analyses, resulting in the loss of 3.8% and 4.5% of cases, respectively.

A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture presence: picture not shown, picture shown) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on answer RTs for correctly selected can't say responses, whose descriptive statistics are presented in Table 3. There was a main effect of picture presence, F_1 (1, 40) = 10.48, MSE_1 = 332737.4, p_1 = .002, $\eta\rho^2{}_1$ = .208, F_2 (1, 44) = 13.29, MSE_2 = 276682.2, p_2 = .001, $\eta\rho^2{}_2$ = .232, where participants answered invalid questions more quickly when they were preceded by a picture (M_1 = 2107.7, SE_1 = 99.5) compared to questions not preceded by a picture (M_1 = 2345.8, SE_1 = 94.1). The main effect of distractor type was not significant by participants, F_1 (2, 80) = 2.18, MSE_1 = 196691.1, p_1 = .120, $\eta\rho^2{}_1$ = .052, F_2 (2, 88) = 6.36, MSE_1 = 299899.9,

p_2 = .003, $\eta\rho^2_1$ = .126, although the item analysis revealed faster answer RTs in response to questions containing an unrelated distractor than either a visually similar or visually dissimilar distractor, which did not differ. Neither analysis indicated a significant two-way interaction, $F_1 < 1$, $F_2 < 1$.

Question Reading Times. To address the influence of distractor type on the ability to integrate the distractor name with the context of the question, reading times for all words that were presented after the distractor name were measured (i.e., post-distractor reading times). Average word-by-word reading times for all words presented after the distractor name were first calculated individually for each participant and item, then the mean for post-distractor reading times was calculated. Post-distractor reading times exceeding 2 SDs from each word-by-word mean were excluded from analyses (3.7% and 4.3%, respectively). A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture presence: picture not shown, picture shown) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on the average post-distractor reading times, and means and standard errors are presented in Table 4. Analyses revealed a marginal main effect of distractor type (by participants only), F_1 (2, 106) = 2.53, MSE_1 = 4428.23, p_1 = .084, $\eta\rho^2_1$ = .046, $F_2 < 1$, in which visually similar questions (M_1 = 465.4, SE_1 = 13.9) and visually dissimilar questions (M_1 = 471.7, SE_1 = 16.4) did not differ from one another (p_1 = .551; p_2 = .611), but both were read more slowly than unrelated questions (M_1 = 451.8, SE_1 = 12.1, p_1 = .034, p_2 = .754, and p_1 = .048, p_2 = .455, respectively). However, there was no main effect of picture presence, F_1 (1, 53) = 1.39, MSE_1 = 7008.8, p_1 = .243, $\eta\rho^2_1$ = .026, $F_2 < 1$, nor an interaction, $F_1 < 1$, F_2 (2, 104) = 1.16, MSE_2= 3904.3, p_2 = .317, $\eta\rho^2_2$ = .022.

Discussion

The present findings suggest a new role for visual concepts in name recognition: Visual similarity between semantically related targets and distractors increased name recognition errors during comprehension, specifically the Moses illusion, in two ways. First, questions containing visually similar distractors increased participants' erroneous selection of target answers compared to unrelated distractors. This increase in target illusions was unique to visually similar distractors and not visually dissimilar distractors, suggesting that participants were mistakenly thinking of the target name but only while reading a distractor that was highly visually similar to the target. Second, participants had reduced detection accuracy when questions contained visually similar distractors, selecting can't say less frequently than questions containing unrelated distractors. While this reduction in accuracy also occurred for questions containing purely semantic visually dissimilar distractors, consistent with previous research where visual similarity was not reported (e.g., Reder & Kusbit, 1991; Shafto & MacKay, 2000), the effect was larger for visually similar distractors. These findings with respect to visual similarity did not result from a speed-accuracy tradeoff, consistent with other research on the Moses illusion and semantic similarity (Reder & Cleeremans, 1990; Reder & Kusbit, 1991; van Jaarsveld et al., 1997; van Oostendorp & de Mul, 1990). Analyses of response times (to correctly choose can't say) and post-distractor reading times indicated that visually similar distractors' greater susceptibility to the illusion was not due to less time spent reading or answering questions containing these distractors: Answer response times and post-distractor reading times were equivalent in questions containing visually similar or visually dissimilar distractors.

Finding that overlapping visual concepts enhanced the Moses illusion above and beyond semantic overlap alone challenges previous explanations regarding the role of shallow semantic processing in solely inducing the Moses illusion (Kamas et al., 1996; Reder & Kusbit, 1991). While pilot testing showed that our visually similar and visually dissimilar distractors were rated as equivalently semantically similar to their associated targets, visually similar distractors nevertheless resulted in more illusions. The fact that visual similarity between targets and distractors enhanced the illusion when names were presented as text suggests that visual information is activated even when the written name, not a face, is encountered.

The results are consistent with interactive activation models such as NST (MacKay, 1987), where illusions result from activation of the target's lexical node, which occurs when priming converges on it from multiple sources (Shafto & MacKay, 2000, 2010). Our findings demonstrate that one of these sources is visual concepts, specifically facial features. In NST, visual concepts are stored and retrieved in a manner similar to other semantic information (MacKay & Burke, 1991) and have the potential to exacerbate the interference from a semantically related distractor, enhancing the illusion. The importance of visual concepts in name recognition is also highlighted by the finding that target picture presentation prior to reading an invalid question improved participants' detection of illusions, evidenced by more can't say responses. Unlike some semantic cuing studies, which specifically directed participants' attention to the source of the illusion (e.g., Reder & Kusbit, 1991), participants in our experiment were given visual information, which is only indirectly related to the fact being tested, and the picture's brief presentation prevented participants from studying it (see Kamas et al., 1996, for parallel conclusions regarding indirect semantic cues). Thus, while shared visual features created interference and caused the illusion, activating the target's visual concept node and emphasizing its unique visual features prior to presenting the question was an effective "cue" for detecting the anomalous distractor in the subsequent question. This occurred even for visually similar distractors, which possess considerable feature overlap with targets but whose subtle visual distinctions were nonetheless sufficient to aid anomaly detection.

Experiment 2

The purposes of Experiment 2 were to: (1) replicate the effect that facial features exacerbate susceptibility to the Moses illusion observed in Experiment 1, and (2) directly investigate the role of the visually similar distractor's facial features in influencing the illusion. Prior presentation of the target's facial features increased correct detection of the illusion in Experiment 1, similar to the effect of presenting semantic facts about the target before question presentation (Reder & Kusbit, 1991). However, research has also shown that presenting a fact about the distractor aids in illusion detection (Kamas et al., 1996). Because Moses illusions are strongest and least likely to be detected when a target and distractor have many overlapping features, emphasizing any salient, non-overlapping features that *differentiate* the two names should likewise decrease illusions and increase accurate detection. Thus, a cue that emphasizes either the target (e.g., *How many sons did Noah have?*) or distractor name (*Which sea did Moses part?*) are equally successful in reducing the illusion because both help to emphasize the incompatibility between an invalid distractor name and the question context. In a similar manner, we hypothesized that seeing a picture of the visually similar distractor will also facilitate detection of the illusion by activating the facial features that are shared with the target, which in turn will highlight the differences between the target and the distractor and generate awareness that the distractor name conflicts with the rest of the information in the Moses illusion question.

Furthermore, to ensure that participants possessed sufficient semantic knowledge of the target name and the corresponding fact being assessed in the question, a knowledge check was administered following presentation of all of the Moses illusion questions. This check ensured participants knew that the target name, and not the distractor name, was the correct name associated with that particular fact, clarifying that any Moses illusions experienced were not a result of insufficient or inaccurate semantic knowledge about the target.

Method

Participants

Participants included 74 young adults (*M* = 18.71, *SD* = 1.5; aged 18-27; 55 females) from general psychology courses at the University of Florida who received partial fulfillment of a course requirement for participation. Participants were English speakers with no known diagnosis of reading difficulties or dyslexia. To avoid the possibility of handedness effects, all participants were self-reported as right-handed.

Materials

Moses Illusion Task. The same 54 experimental general knowledge questions were used from Experiment 1, except that the multiple-choice options for one question (*Seth Rogan*) were modified to eliminate unintended overlap between one of the answer choices and one of the distractor names. Additionally, Experiment 2 contained only invalid versions of the experimental questions. The 40 filler questions from Experiment 1 along with 14 new filler questions were used to ensure an equal number of valid and invalid questions, but fillers were not analyzed further.

Like Experiment 1, the questions were randomly presented and counterbalanced so that participants only received one question about a particular target. Participants saw 18 of each distractor type (visually similar, visually dissimilar, and unrelated) for the 54 experimental questions along with the 54 fillers, totaling 108 questions. Within each version, half of the questions were preceded by a target picture used in Experiment 1, while the other half were preceded by a picture of the visually similar distractor, with picture type counterbalanced across participants. Filler questions were preceded by an unrelated picture so that all questions in the experiment were preceded by a picture. Like target pictures, visually similar distractor pictures and unrelated pictures were 4" x 4" color Google images.

Procedure

The procedure for presenting the pictures and general knowledge questions was identical to Experiment 1. Changes were made to the keys required for responding to more effectively capture response times, i.e., by positioning the keys for the various answer choices at an equivalent distance from the key that revealed each word. Instead of pressing the spacebar to bring on each new word in the question, a blue sticker was placed over the “v” key, and participants were instructed to press this “blue key”. Instead of pressing the a, b, c, d, or e keys to select a response to questions, stickers that had the numbers 1, 2, 3, 4, and 5 were placed over the d, f, g, h, and j keys, respectively, and participants were instructed to select the numbered key associated with the correct response. For all ratings, participants were instructed to press the appropriate keys with their right index finger.

After all of the Moses illusion questions were presented, a knowledge check was included to assess participants' familiarity with the semantic knowledge presented in those questions. In this task, participants were presented with re-worded versions of the Moses illusion questions so that the answer corresponded to the correct person’s name (e.g., *Which actor is featured in the movie 'Ocean's 11', attempting to rob a casino?*). Participants were informed that all of these questions were originally invalid in the main experiment, and the purpose of this task was to allow them to demonstrate their knowledge of the correct answer even if they failed to recognize that the original question was invalid. Participants were given the instruction “Do NOT try to recall the original question; focus only on giving the correct answer to the reworded question”.

Participants first saw the reworded question appear in the middle of the screen, and participants were instructed to type the correct answer if they knew it. Then, a set of multiple choice options appeared below the question, which contained the correct name, visually similar distractor, visually dissimilar distractor, and unrelated name in random order, and participants were instructed to choose the correct name by pressing the associated 1, 2, 3, or 4 key. If they did not know which name was the correct name, they were instructed to press 5 to indicate don't know. Following the instructions, participants completed three practice trials to familiarize them with the task.

Results

As with Experiment 1, individual cases in which participants took longer than six seconds to make a response and subsequently lost the opportunity to choose a multiple choice answer (timed out responses; 1.4% of cases) were excluded from analyses. All of the following analyses were constrained to cases where participants correctly identified the associated target name from the knowledge check. Means and standard errors for selecting the various answer choices in response to invalid questions are shown in Table 5.

Target illusions. As illustrated in Table 5, participants who chose an incorrect answer were most likely to choose the target answer (i.e., experience a target illusion) rather than one of the two non-target answer choices. A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture type: target picture, visually similar picture) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on mean percent target illusions. Consistent with Experiment 1, analyses illustrated a significant main effect of distractor type shown in Figure 5, F_1 (2, 144) = 5.22, MSE_1 = .033, p_1 =. 007, $\eta\rho^2_1$ = .068, F_2 (2, 100) = 5.14, MSE_2 = .032, p_2 = .008, $\eta\rho^2_2$ = .093: Participants experienced more target illusions for questions containing visually similar distractors compared to those containing either visually dissimilar distractors (p_1 = .023, p_2 = .043) or unrelated distractors (p_1 = .003, p_2 = .005), which did not differ (p_1 = .421, p_2 = .399). The main effect of picture type was not significant, F_1 (1, 72) = 2.09, MSE_1 = .026, p_1 =. 152, $\eta\rho^2_1$ = .028, F_2 (2, 50) = 3.73, MSE_2 = .014, p_2 = .059, $\eta\rho^2_2$ = .069, nor was the two-way interaction between distractor type and picture type, $F_1 < 1$, $F_2 < 1$.

Can't say responses. Invalid questions were also analyzed for participants' selection of the can't say option from the possible multiple-choice answers, i.e., identifying an inconsistency in the question. A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture type: target picture, visually similar picture) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on the mean percentage of can't say responses. Unlike Experiment 1, analyses indicated no significant main effects of distractor type (see Figure 5; although the item analysis revealed a marginal main effect, which was due to significantly fewer can't say responses for questions containing visually similar distractors than unrelated distractors), F_1 (2, 144) = 1.91, MSE_1 = .057, p_1 = .151, $\eta\rho^2_1$ = .026, F_2 (2, 100) = 2.35, MSE_2 = .053, p_2 = .100, $\eta\rho^2_2$ = .045, or picture type, $F_1 < 1$, $F_2 < 1$, nor was the two-way interaction significant, F_1 (2, 144) = 1.02, MSE_1 = .033, p_1 = .362, $\eta\rho^2_1$ = .014, $F_2 < 1$.

Response times. Response times (answer RTs, in ms) for participants' selection of the can't say option for invalid questions were analyzed. To identify outliers, individual means for participants and items were calculated for answer RTs across conditions, and RTs exceeding 2 *SD*s from each mean were excluded from analyses, resulting in the loss of 5.8% of cases in the participant analysis and 6.4% of cases in the item analysis.

A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture type: target picture, visually similar picture) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on answer RTs, whose descriptive statistics are presented in

Table 6. There was a main effect of distractor type, F_1 (2, 126) = 7.69, MSE_1 = 153278.1, p_1 = .001, $\eta\rho^2_1$ = .109, F_2 (2, 104) = 6.19, MSE_2 = 182324.9, p_2 = .003, $\eta\rho^2_2$ = .106, and a main effect of picture type, F_1 (1, 63) = 7.04, MSE_1 = 351250.1, p_1 = .01, $\eta\rho^2_1$ = .100, F_2 (1, 52) = 7.61, MSE_2 = 138427.8, p_2 = .008, $\eta\rho^2_2$ = .128. These main effects were qualified by a significant interaction (marginally significant in item analysis), F_1 (2, 126) = 3.93, MSE_1 = 173198.2, p_1 = .022, $\eta\rho^2_1$ = .059, F_2 (2, 104) = 2.46, MSE_2 = 157406.4, p_2 = .091, $\eta\rho^2_2$ = .045. Decomposing the interaction revealed that for cases where the *target* picture was presented before the question, participants' RTs to select can't say were equivalent regardless of which distractor was presented (p_1s >.112, p_2s > .064). However when a *visually similar* picture was presented before the question, participants' RTs for questions containing visually similar and visually dissimilar distractors (p_1 =.149, p_2 = .761), which did not differ, were slower relative to questions containing unrelated distractors (p_1 =.002, p_2 = .009, and p_1 <.001, p_2 = .005, respectively).

Question reading times. As with Experiment 1, post-distractor reading times were measured to examine how distractor type influenced the ability to integrate the distractor name with the information presented in the question. Post-distractor reading times exceeding 2 *SD*s from each word-by-word mean were excluded from analyses (3.7% and 4.3%, respectively). A 3 (distractor type: visually similar, visually dissimilar, unrelated) x 2 (picture type: target picture, visually similar picture) repeated-measures ANOVA was conducted by participants (F_1) and items (F_2) on the average post-distractor reading times, and means and standard errors are presented in Table 7. There was a significant main effect of distractor type in the participant analysis only, F_1 (2, 146) = 3.47, MSE_1 = 1950.6, p_1 = .034, $\eta\rho^2_1$ = .045, F_2 (2, 106) = 1.10, MSE_2 = 1381.5, p_2 = .337, $\eta\rho^2_2$ = .020, in which post-distractor reading times were slower for visually similar questions (M_1 = 441.5, SE_1 = 14.1) and visually dissimilar questions (M_1 =

444.2, SE_1 = 14.3) compared to unrelated questions (M_1 = 431.4, SE_1 = 12.5, p_1 = .034, p_2 = .294, and p_1 = .007, p_2 = .183, respectively). However, reading times for visually similar and visually dissimilar questions did not differ from one another (p_1 = .654, p_2 = .675). There was no significant main effect of picture type, $F_1 < 1$, $F_2 < 1$, nor a significant two-way interaction, F_1 (2, 146) = 1.56, MSE_1 = 1472.6, p_1 = .241, $\eta\rho^2_1$ = .021, $F_2 < 1$.

Discussion

Replicating Experiment 1, the results of Experiment 2 demonstrated that visually similar distractors increased the likelihood of experiencing Moses illusions compared to other distractors. Visually similar distractors led to more target illusions than either visually dissimilar distractors or unrelated distractors, evidenced by more frequent selection of the multiple-choice answer that was consistent with the target as the agent of the question. These results cannot be explained by participants' lack of familiarity with the target or believing that the visually similar distractor belonged in the question: Participants experienced target illusions despite later identifying the target as the correct name that belonged in the question during the knowledge check. However, unlike Experiment 1, distractor type did not differentially influence participants' correct detection of the illusion, i.e., selecting can't say (although the pattern did emerge in the item analysis). One possibility is that accurate detection via a can’t say response may be less sensitive in detecting the effects of visual similarity on Moses illusions. Whereas saying can't say indicates that an anomaly was broadly detected, it does not clearly specify what the anomaly was; participants could have selected can't say when they thought that something was wrong in the question but were unsure what, or they could have mistakenly thought that some other part of the question, not the distractor name, was incorrect. In contrast, target illusions indicate the specific selection of the target as the correct answer, which clearly demonstrates that the illusion was experienced. Indeed, target illusions are more consistent with how the Moses illusion is frequently described, with people producing the target answer "two" despite knowing that Noah sailed the ark.

The above findings occurred irrespective of the picture that preceded the question. Presenting a picture of the visually similar distractor did not differentially influence participants' susceptibility to the illusion compared to a picture of the target, either in experiencing target illusions or in correctly detecting the illusion. We interpret these results theoretically to suggest that presenting a picture of a visually similar distractor primes salient visual features that are shared with the target, allowing it to influence the Moses illusion similarly to a picture of the target. These findings also extend results from past Moses illusion studies that used semantic facts as cues, showing that detection accuracy was similarly improved when participants read either a fact about the target or a fact about the distractor (Kamas et al., 1996; Reder & Kusbit, 1991).

However, the type of picture did influence the RTs for selecting can't say, where presenting the visually similar picture (but not the target picture) slowed responses for questions containing visually similar or visually dissimilar distractors relative to unrelated distractors. These findings suggest that even though the visually similar picture was helpful in detecting the illusion, it slowed detection when either semantic distractor was present in the question. This suggests that activation of the visually similar distractor's unique visual features, the ones different from the target, creates some interference when a semantically plausible distractor is present in the question, but this interference is superseded by the facilitation from the shared features between the visually similar distractor and target.

Analyses of post-distractor reading times were consistent with Experiment 1 and demonstrated that visually similar distractors' greater susceptibility to the illusion cannot be attributed to reading those questions more quickly. Post-distractor reading times were longer for visually similar and visually dissimilar questions compared to unrelated questions, which may reflect greater interference from reading the semantic distractors with the context of the question. Nonetheless, these slowed reading times did not translate into fewer target illusions or increased accuracy of detecting illusions. Furthermore, reading times for sentences containing visually similar and visually dissimilar distractors were equivalent, again underscoring that increased target illusions for visually similar questions compared to visually dissimilar questions did not result from participants reading more hastily or less thoroughly.

General Discussion

The Moses illusion has traditionally been explained to result from shallow semantic processing: Individuals generally only check a subset of words in a question against their stored semantic knowledge such that distractor names with high semantic overlap (Moses) can be substituted with a target name (Noah) without being noticed (Kamas et al., 1996; Reder & Kusbit, 1991). However, recent research has challenged this idea by showing that phonological overlap between distractors can independently induce the Moses illusion and, in combination with semantic overlap, exacerbate it (Shafto & MacKay 2000, 2010). A unified explanation to include both semantic and phonological effects can be accommodated within NST in terms of convergent priming, in which the distractor name is miscomprehended *as* the target name. This explanation motivated the present study to examine other factors that could potentially influence susceptibility to the Moses illusion via convergent priming, namely overlapping facial features between the target and distractor. Two experiments explored the role of shared facial features by investigating (1) whether questions containing a semantic distractor that was visually similar to the target would have more Moses illusions, and (2) whether brief presentation of a picture prior to the question, either the target or the visually similar distractor, would reduce susceptibility to the illusion.

In both experiments, visually similar distractors led to more Moses illusions (i.e., selection of the "target" answer) than either visually dissimilar or unrelated distractors. Both piloting and the knowledge check (Experiment 2) confirmed that increases in illusions for visually similar distractors were not due to lack of familiarity with the target, distractor, or factual information presented in the question. Instead, these results suggest that when individuals read questions with visually similar distractors, they errantly activated the target name and subsequently chose the target answer. The fact that visually similar distractors uniquely led to more Moses illusions compared to other distractors provides support for Shafto and MacKay's (2000, 2010) convergent priming explanation and also helps to clarify the role that visual concepts play in everyday person recognition. First, these results comport with theories like NST that suggest facial features constitute a distinct visual concept system, but are stored alongside and connect to other semantic information such that even verbal tasks that do not explicitly require face recognition or visualization (e.g., reading a name) can lead to the retrieval of visual information. Further, because visual features (like other semantic information) can be shared by multiple people, overlapping visual features provide additional routes by which priming can be transmitted from the distractor to the target, enhancing the possibility of experiencing an illusion.

Further, the fact that visually similar distractors increased the illusion when names were presented as text suggests that visual information is activated even in cases where a face is not explicitly encountered, such as the case of reading a written name. It is worth noting that these explanations are not compatible with interactive models of face recognition (e.g., Interactive

Activation and Competition model; Bruce & Young, 1986; Burton & Bruce, 1992), which instead propose that facial features ("facial recognition units") are stored independently from semantic information ("semantic information units"). More importantly, these models suggest that visual features can only become activated when viewing or imagining a face; reading a name only establishes familiarity with the person (activating "person identity nodes"; Cabeza et al., 1997) and therefore cannot explain why visually similar distractors would elicit more illusions than visually dissimilar distractors. Thus, encapsulating both observations in a single explanation – that visual similarity leads to more Moses illusions than semantic similarity alone and visual features can be activated in a non-visual task – requires theoretical assumptions of interactive activation between visual and semantic features consistent with those in NST.

With regard to prior picture presentations, Experiment 1 illustrated that viewing salient facial features of the target increased accurate detection of the illusion relative to when no picture was presented, and Experiment 2 illustrated that presenting visually similar pictures or target pictures led to an equivalent number of Moses illusions. These results expand on past research with text-based semantic cues (e.g., Kamas et al., 1996; Reder & Kusbit, 1991) in several ways. First, emphasizing salient visual characteristics about the target via a picture, even when presented briefly and when the picture is not the target, leads to an increase in illusion detection. Second, such emphasis can theoretically occur indirectly through shared visual features when a picture of a visually similar distractor is presented. In both cases, picture presentation serves to highlight visual features (which may in turn prime semantic features) that help to distinguish the target from the distractor name and likewise underscore the incompatibility between the distractor name and the information in the question.

One limitation of the present research was its inability to include a visually similar, semantically unrelated condition, e.g., a non-actor who looks like Brad Pitt. This condition would have clarified whether visual similarity can independently induce Moses illusions, which would be predicted by theories such as NST but would be problematic for theories that require semantic overlap for Moses illusions to occur. Unfortunately, it was impossible to identify target-distractor pairs for this condition, in part because of the limited resources for identifying visual similarity. The available websites focused exclusively on celebrities so that all of the listed people were in the same occupation, most likely because these are the people with whom college students are most familiar and find recognizable. Nonetheless, the present study demonstrated that facial features do play a role in exacerbating Moses illusions above and beyond overlapping semantics.

While previous research has demonstrated that semantic similarity can result in the Moses illusion relative to unrelated distractors (e.g., Brédart & Modolo, 1988; Erickson & Mattson, 1981; Reder & Kusbit, 1991; Shafto & MacKay, 2000; van Oostendorp & de Mul, 1990), we found mixed evidence of this for our purely semantic, i.e., visually dissimilar, distractors. While Experiment 1 replicated Moses illusions for visually dissimilar distractors in terms of can't say responses, this did not occur in Experiment 2, nor was there an increased susceptibility to target illusions in either experiment. What are possible reasons for these inconsistencies in demonstrating Moses illusions for semantic distractors? First, other studies may have contained multiple sources of overlap (e.g., Moses and Noah were both biblical characters, witnessed miracles, and spoke directly to God) to define shared semantics, whereas our definition of semantic overlap was based on a single biographical fact (occupation). As aforementioned, distractors that share many semantic features with their target (e.g., *Moses*, *Noah*) are more likely to induce illusions than distractors that share only a few semantic features with their target (*Moses*, *Adam*; van Jaarsveld et al., 1997; van Oostendorp & de Mul, 1990). Second, some previous studies that focused on semantic overlap actually included targets and distractors that overlapped both semantically and phonologically (e.g., *Joshua/Jonah*; from Song & Schwartz, 2008; *Edison/Franklin; RFK/JFK; thermostat/thermometer*; from Reder & Kusbit, 1991), which has been shown to enhance the illusion (the mega-Moses illusion; Shafto & MacKay, 2000), whereas our targets and distractors did not share phonology. Additionally, past studies have not reported visual similarity as a potential source of overlap when constructing stimuli, so it is possible that in some cases, purely semantic distractors in previous studies may have unintentionally contained visual overlap, which would enhance the illusion effect (e.g., the target *Bruce Lee* and distractor *Jackie Chan*, which were used in Shafto & MacKay, 2010, are noted as visually similar on www.totallylookslike.com). Nevertheless, these issues emphasize the importance for identifying all potential sources of overlap (and the amount of overlap) when conducting future Moses illusion studies.

In sum, these results challenge traditional interpretations of the Moses illusion as a purely semantically-induced phenomenon by revealing that visual similarity can play a critical role. Names automatically activate facial features of the corresponding referent, even in a task where those features are not necessary for successful name recognition. More generally, these findings extend beyond the Moses illusion to shed light on the organization of visual concepts in relation to other person-specific information, supporting a view where the two are accessed in parallel and can work interactively as opposed to in isolation of one another. Theoretically, this organization would suggest that visual information may also be relevant to errors in name retrieval, i.e., visual similarity may moderate the degree to which individuals experience proper name retrieval failures, a particularly common memory error. This experiment is the starting point for contributing to a more comprehensive account of how non-linguistic factors like visual concepts influence storage and retrieval of proper names.

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Table 1

Means and standard errors for familiarity ratings and similarity ratings in the pilot study

	Distractor Type		
	Visually Similar Distractor	Visually Dissimilar Distractor	Unrelated Distractor
Pilot Rating	*M (SE)*	*M (SE)*	*M (SE)*
Familiarity Rating[1]	3.34 (.12)	3.63 (.12)	3.16 (.12)
Semantic Similarity Rating[2]	2.36 (.04)	2.27 (.05)	1.34 (.04)
Visual Similarity Rating[3]	2.21 (.05)	1.51 (.04)	1.45 (.05)

[1]Familiarity ratings are based on a 5 point scale (1= Completely unfamiliar, 5= Very familiar)

[2]Semantic similarity ratings are based on a 3 point scale (1= Completely unrelated, 3= Strongly related)

[3]Visual similarity ratings are based on a 3 point scale (1 = Not similar at all, 3 = Highly similar)

Table 2

Responses to invalid questions as a function of distractor type and picture presence in Experiment 1

Picture Presence	% Target Illusions		% Can't Say		% Other Answers		% Don't Know	
	M (%)	*SE (%)*	*M (%)*	*SE (%)*	*M (%)*	*SE (%)*	*M (%)*	*SE (%)*
Picture Not Presented								
Visually Similar Distractor	20.6	2.5	43.1	3.9	4.5	1.1	31.8	3.1
Visually Dissimilar Distractor	19.1	2.7	46.5	3.9	4.3	1.3	30.1	3.0
Unrelated Distractor	17.5	2.8	51.2	3.7	2.6	0.8	28.7	3.0
Picture Presented								
Visually Similar Distractor	22.7	2.9	51.9	3.8	3.7	1.0	21.7	2.5
Visually Dissimilar Distractor	16.4	2.4	57.9	3.8	2.2	0.8	23.5	2.7
Unrelated Distractor	17.3	2.8	61.4	4.2	2.6	1.0	18.6	2.7

Table 3

Answer RTs (in ms) for selecting can't say to invalid questions as a function of distractor type and picture presence in Experiment 1

Distractor Type	Picture Not Presented		Picture Presented	
	M	*SE*	*M*	*SE*
Visually Similar Distractor	2372.8	114.6	2185.9	124.6
Visually Dissimilar Distractor	2407.9	120.7	2105.1	112.5
Unrelated Distractor	2256.6	101.9	2032.1	115.5

Table 4

Reading times (in ms) of post-distractor words as a function of distractor type and picture presence in Experiment 1

Distractor Type	Picture Not Presented		Picture Presented	
	M	*SE*	*M*	*SE*
Visually Similar Distractor	464.2	12.5	466.7	14.5
Visually Dissimilar Distractor	466.1	14.4	477.3	22.5
Unrelated Distractor	442.1	11.5	461.5	14.3

Table 5

Responses to invalid questions as a function of distractor type and picture type in Experiment 2 for cases where the correct answer was chosen on the knowledge check

Picture Type	% Target Illusions		% Can't Say		% Other Answers		% Don't Know	
	M (%)	*SE (%)*	*M (%)*	*SE (%)*	*M (%)*	*SE (%)*	*M (%)*	*SE (%)*
Target Picture								
Visually Similar Distractor	20.0	2.6	65.5	3.2	3.3	1.0	11.3	1.8
Visually Dissimilar Distractor	14.1	2.5	70.3	3.1	1.9	0.6	13.7	2.1
Unrelated Distractor	14.4	2.5	68.2	3.4	4.0	1.0	13.5	2.1
Visually Similar Picture								
Visually Similar Distractor	17.7	2.7	62.3	3.6	5.1	1.3	14.8	2.2
Visually Dissimilar Distractor	13.8	2.3	66.1	3.2	2.8	1.0	17.3	2.4
Unrelated Distractor	10.2	2.3	69.7	3.8	4.3	1.7	15.8	2.5

Table 6

Answer RTs (in ms) for selecting can't say to invalid questions as a function of distractor type and picture type in Experiment 2

Distractor Type	Target Picture		Visually Similar Picture	
	M	*SE*	*M*	*SE*
Visually Similar Distractor	1834.2	92.8	2090.4	84.5
Visually Dissimilar Distractor	1945.1	75.3	2177.2	89.4
Unrelated Distractor	1872.9	93.2	1865.6	77.5

Table 7

Reading times (in ms) of post-distractor words as a function of distractor type and picture type in Experiment 2

Distractor Type	Target Picture		Visually Similar Picture	
	M	*SE*	*M*	*SE*
Visually Similar Distractor	445.1	14.8	438.0	13.9
Visually Dissimilar Distractor	444.1	13.9	444.3	15.5
Unrelated Distractor	427.1	12.5	435.7	13.2

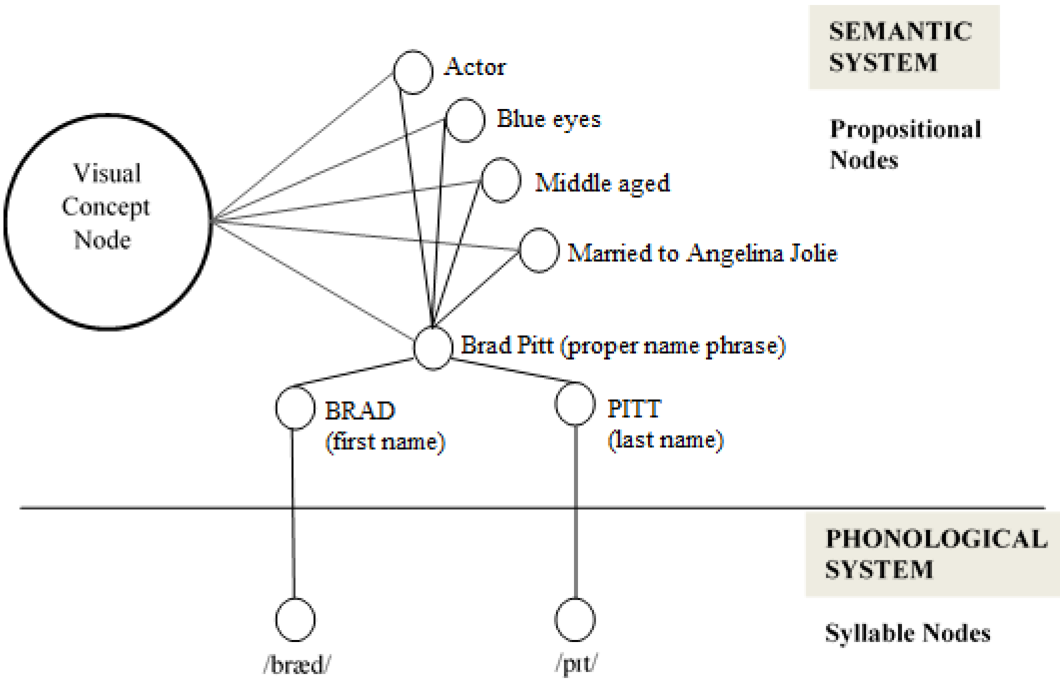

Figure 1. Semantic and phonological systems proposed by NST to illustrate the representation of a proper name *Brad Pitt*. Information about names is represented in multilevel systems, including propositional nodes, visual concept nodes, lexical nodes, and phonological nodes. Visual concept nodes constitute an independent system for visual information that connects directly to the proper name phrase (to represent a person's looks) and to other visualizable propositions in the semantic system (e.g., blue eyes). Adapted from MacKay and Burke (1991, p.9).

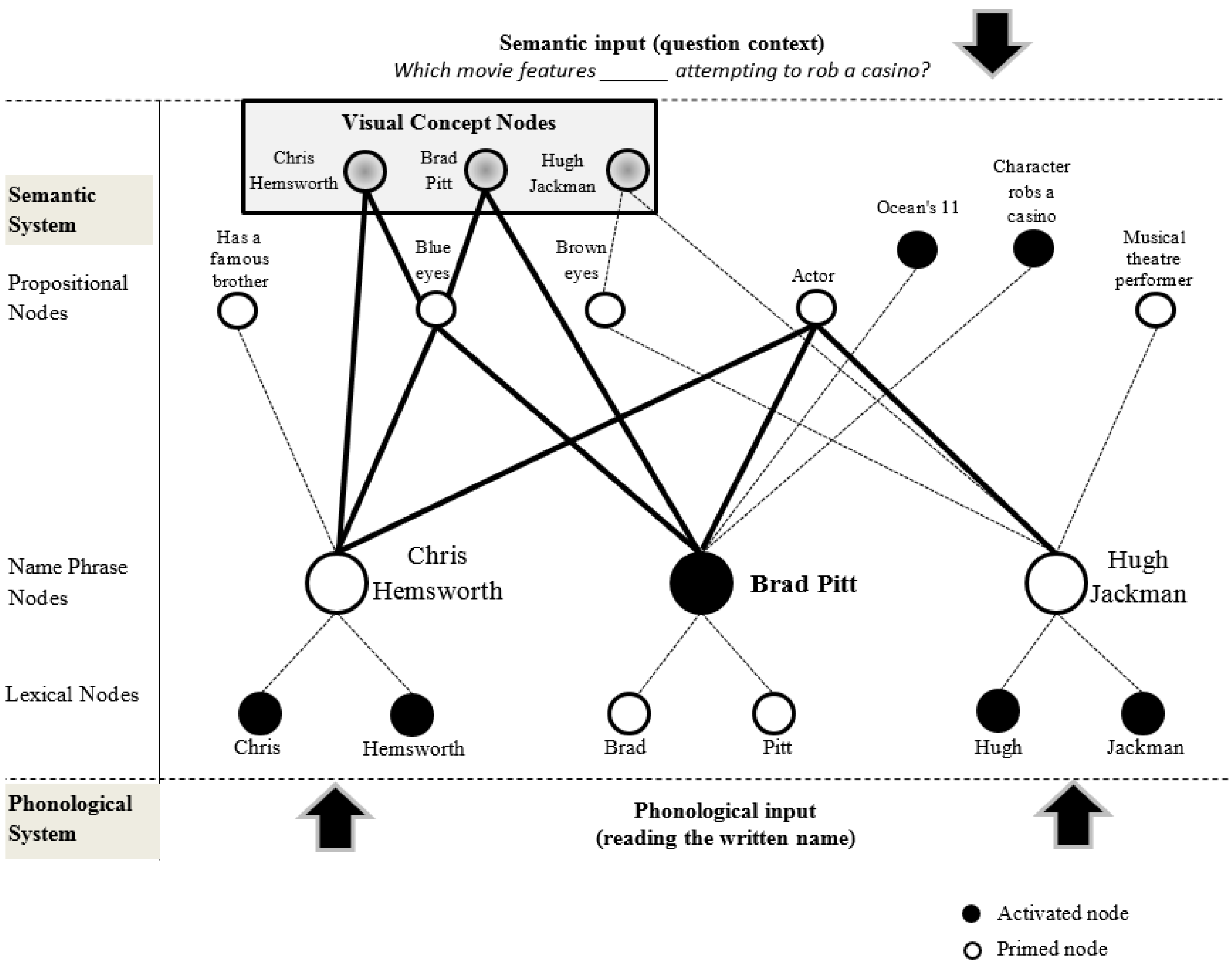

Figure 2. Theoretical explanation for how visually similar semantic distractors (*Chris Hemsworth*) contribute more priming to the target name (*Brad Pitt*) than visually dissimilar semantic distractors (*Hugh Jackman*) due to shared connections between visual concept nodes. Shared links are bolded for emphasis. Adapted from Shafto and MacKay (2000, p. 374) with permission from Sage Publications.

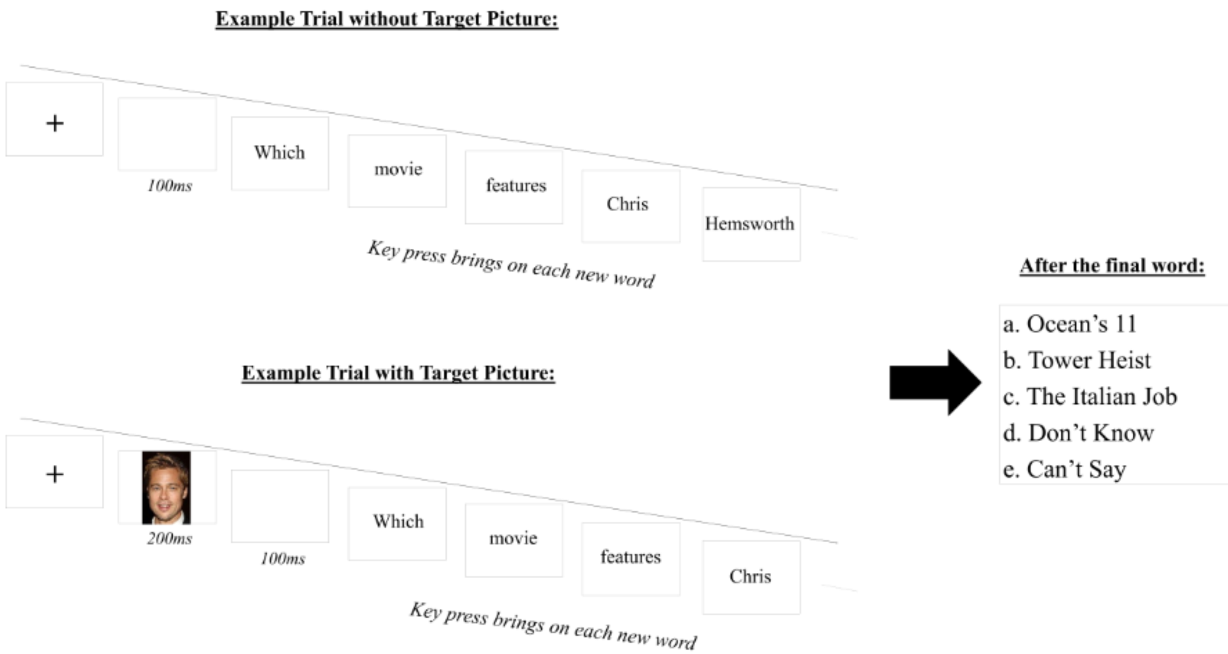

Figure 3. Example trials from Experiment 1. Questions were preceded by a target picture on half the trials. Each question was presented word-by-word, with previous words disappearing so that only one word was presented onscreen at a time. When the last word of the question disappeared, the multiple-choice options appeared onscreen.

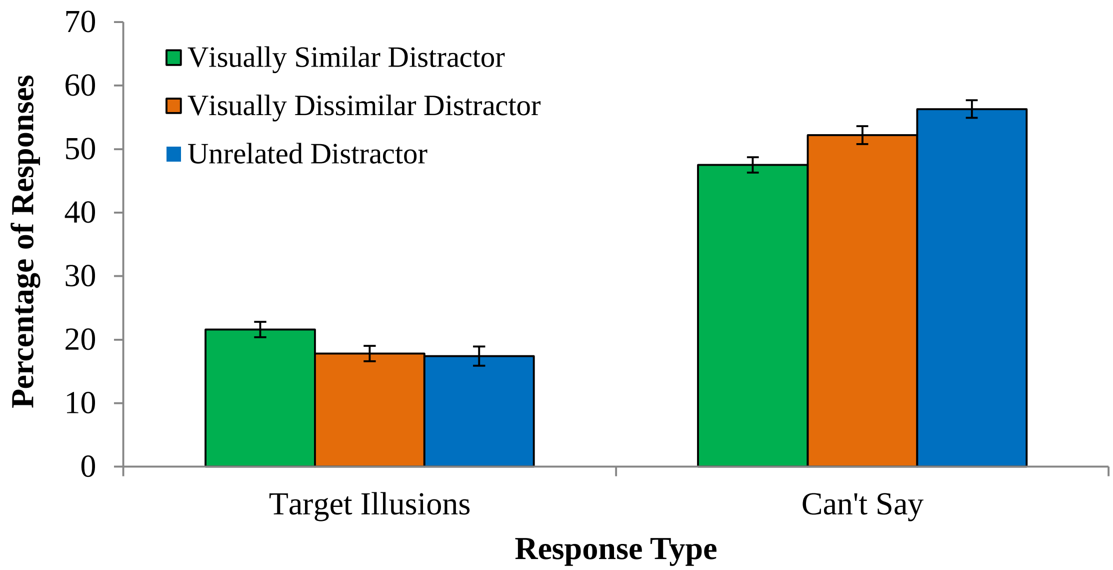

Figure 4. Mean percentage of target illusions and can't say responses for each distractor type (visually similar, visually dissimilar, unrelated) in Experiment 1. Bars represent ± 1*SE*.

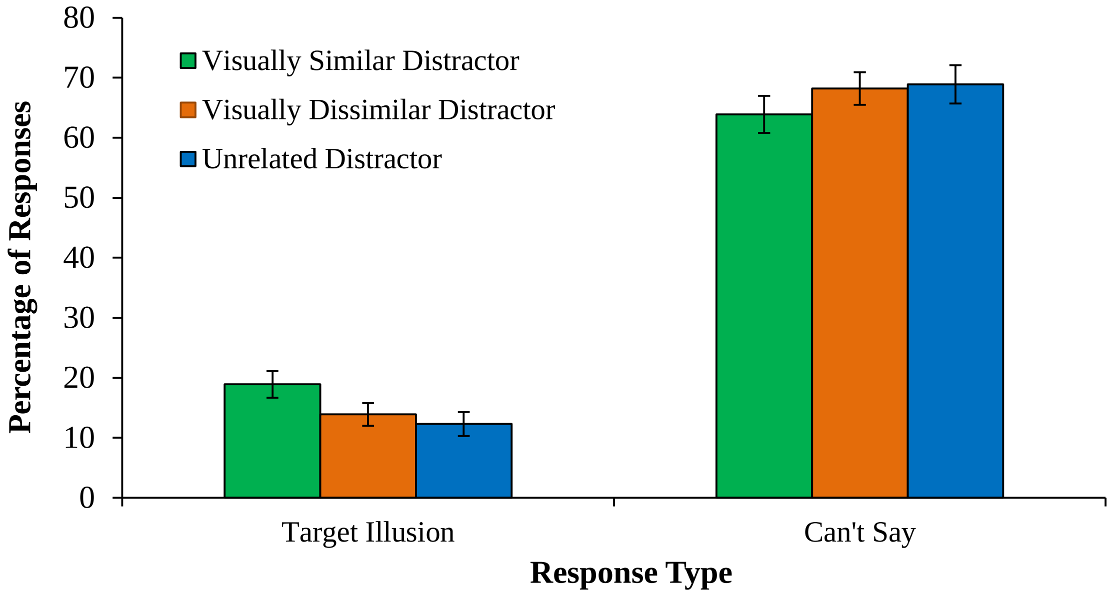

Figure 5. Mean percentage of target illusions and can't say responses for each distractor type (visually similar, visually dissimilar, unrelated) in Experiment 2. Bars represent ± 1*SE*.

Appendix

Table A

Illusion questions, target answers, target names, and associated distractor names

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which movie featuring songs by ABBA had ______ play a bride-to-be trying to find her father?	Mamma Mia	Amanda Seyfried (Actor)	Dakota Fanning	Megan Fox	Colbie Caillat (Singer)
Which rap artist collaborated with ______ to sing 'Empire State of Mind'?	Jay Z	Alicia Keys (Singer)	Leona Lewis	Natasha Bedingfield	Nastia Liukin (Athlete)
Which movies feature ______ as a teenager destined to become queen of the Kingdom of Genovia?	The Princess Diaries	Anne Hathaway (Actor)	Liv Tyler	Hayden Panettiere	Britney Spears (Singer)
Which style of music is associated with ______ through songs like Complicated, SK8R Boi, and Girlfriend?	Punk	Avril Lavigne (Singer)	Taylor Swift	Ashley Tisdale	McKayla Maroney (Athlete)
Which movie features ______ as an aggressive gym owner trying to take over his competitor's gym?	Dodgeball	Ben Stiller (Actor)	Steve Carell	Jim Carrey	Tim McGraw (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which movie features ______ attempting to rob a casino?	Ocean's 11	Brad Pitt (Actor)	Chris Hemsworth	Hugh Jackman	Rick Santorum (Politician)
Which action movies have ______ as a NYC and LA police detective?	Die Hard	Bruce Willis (Actor)	Jason Statham	George Clooney	Elton John (Singer)
Which movies have ______ as one of three female private investigators?	Charlie's Angels	Cameron Diaz (Actor)	Renee Zellweger	Angelina Jolie	Sara Evans (Singer)
Which movie has ______ playing a wicked queen who wants to kill her beautiful stepdaughter?	Snow White and the Huntsman	Charlize Theron (Actor)	Katherine Heigl	Meg Ryan	Paula Abdul (Singer/TV Personality)
Which cable channel has ______ hosting a self-named late night talk show?	E!	Chelsea Handler (Actor/TV Personality)	Elizabeth Banks	Joan Cusack	Sarah McLachlan (Singer)
Which style of fighting does ______ do in action movies?	Martial Arts	Chuck Norris (Actor)	Tim Allen	Robin Williams	Billy Joel (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which sitcom had ______ playing a chef with obsessive-compulsive tendencies and living with her pal Rachel?	Friends	Courteney Cox (Actor)	Demi Moore	Jodie Foster	LeeAnn Rimes (Singer)
Which movie had ______ play a cashier who tries to win an attractive co-worker's attention?	Employee of the Month	Dane Cook (Actor/ Comedian)	Jeff Dunham	Vince Vaughn	Josh Groban (Singer)
Which movies had ______ play a young wizard hunted down by the dark Lord?	Harry Potter	Daniel Radcliffe (Actor)	Elijah Wood	Adam Brody	Clay Aiken (Singer)
Which baseball team signed ______ for eighteen seasons, the only team he played for?	New York Yankees	Derek Jeter (Athlete)	Alex Rodriguez	Mark Sanchez	Marc Anthony (Singer)
Which comedy movie has ______ embracing a rumor that she is promiscuous?	Easy A	Emma Stone (Actor)	Lindsay Lohan	Victoria Justice	Carly Rae Jepsen (Singer)
Which movie had ______ play a disfigured, masked man who terrorizes a Paris musical theatre company?	Phantom of the Opera	Gerard Butler (Actor)	Russell Crowe	Tom Cruise	Kurt Cobain (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which hit song by ______ has the lyrics 'this shit is bananas'?	Hollaback Girl	Gwen Stefani (Singer)	Christina Aguilera	Kelly Clarkson	Anna Kournikova (Athlete)
Which film features ______ as a bookshop owner who falls in love with a famous movie star?	Notting Hill	Hugh Grant (Actor)	Seth Meyers	Owen Wilson	Blake Shelton (Singer)
What Disney show had ______ playing Miley Cyrus's older brother?	Hannah Montana	Jason Earles (Actor)	Neil Patrick Harris	Macaulay Culkin	Adam Lambert (Singer)
Which movie featured ______ as the owner of an adorable but neurotic, naughty dog?	Marley and Me	Jennifer Aniston (Actor)	Kristen Wiig	Reese Witherspoon	Regina Spektor (Singer)
Which comedy has ______ playing a young girl who makes a wish and becomes middle-aged overnight?	13 going on 30	Jennifer Garner (Actor)	Hilary Swank	Gwyneth Paltrow	Celine Dion (Singer)
Which MTV reality show featured ______ in her day-to-day life with her husband?	Newlyweds	Jessica Simpson (Actor/Singer)	Faith Hill	Mariah Carey	Mia Hamm (Athlete)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
What disease was the wife of ______ battling while he was having an affair?	Cancer	John Edwards (Politician)	Rick Perry	Bill Clinton	Steve Martin (Actor)
Which African-American singer collaborated with ______ to make the song 'No Air'?	Chris Brown	Jordin Sparks (Actor/Singer)	America Ferrera	Raven-Symoné Pearman	Gabby Douglas (Athlete)
Which witty, perceptive sidekick does ______ play in the 'Sherlock Holmes' movies?	Watson	Jude Law (Actor)	Ewan McGregor	Christian Bale	Dan Brown (Author)
On which reality tv program was ______ declared the champion twice?	Dancing with the Stars	Julianne Hough (Actor/Singer)	Miley Cyrus	Miranda Cosgrove	Kate Middelton (One-News Wonder)
Which romantic comedy has ______ writing a magazine article about ways women can ruin relationships?	How to Lose a Guy in 10 Days	Kate Hudson (Actor)	Blake Lively	Sandra Bullock	Sara Bareilles (Singer)
Which actor was previously married to ______ and is a committed follower of Scientology?	Tom Cruise	Katie Holmes (Actor)	Maggie Gyllenhaal	Tara Reid	Nelly Furtado (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
What genre of music did ______ originally sing before her debut pop song 'I Kissed a Girl'?	Gospel	Katy Perry (Singer)	Zooey Deschanel	Ellie Goulding	Hope Solo (Athlete)
Who is ______ 's boyfriend, with whom she recently had 'North', her first child?	Kanye West	Kim Kardashian (Actor)	Nicole Scherzinger	Kelly Ripa	Danica Patrick (Athlete)
Which film has ______ playing the love interest of a man with insect-like superpowers?	Spiderman	Kirsten Dunst (Actor)	Drew Barrymore	Jessica Biel	Lindsey Vonn (Athlete)
Which movies have ______ playing a human who falls in love with a vampire?	Twilight	Kristen Stewart (Actor)	Emma Watson	Mandy Moore	Missy Franklin (Athlete)
What infamous 'material' did______ wear to the MTV Video Music Awards in 2010?	Meat	Lady GaGa (Singer)	Amy Winehouse	Alanis Morissette	Monica Lewinsky (One-News Wonder)
Which movie features ______ as a lawyer working a case with a sorority-girl, Harvard-law student?	Legally Blonde	Luke Wilson (Actor)	David Arquette	Ashton Kutcher	Joey Fatone (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which suspense movies feature ______ as a CIA agent with no memory?	Bourne	Matt Damon (Actor)	Leonardo DiCaprio	Tom Hardy	Nick Carter (Singer)
Which movie has ______ playing a former stripper who owns a strip club?	Magic Mike	Matthew McConaughey (Actor)	Bradley Cooper	Will Ferrell	Luke Bryan (Singer)
Which Chinese city featured ______ winning eight Olympic gold medals in swimming?	Beijing	Michael Phelps (Athlete)	Eli Manning	Tom Brady	Johnny Depp (Actor)
Which movie has ______ playing the girlfriend of a man whose best friend is a talking stuffed bear?	Ted	Mila Kunis (Actor)	Vanessa Hudgens	Uma Thurman	Ingrid Michaelson (Singer)
Which movie has ______ playing a ballet dancer who slowly loses her mind?	Black Swan	Natalie Portman (Actor)	Keira Knightley	Amy Adams	Maria Sharapova (Athlete)
Which movies have ______ playing a blacksmith who fights the living dead to save the woman he loves?	Pirates of the Caribbean	Orlando Bloom (Actor)	Justin Timberlake	Nicolas Cage	Chris Daughtry (Singer)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which movie has ______ playing a salesman whose wild behavior forces him into a Big Brother program?	Role Models	Paul Rudd (Actor)	Ben Affleck	Brendan Fraser	Michael Buble (Singer)
Which movie stars ______ as a woman with Alzheimer's whose husband reads her stories from his journal?	The Notebook	Rachel McAdams (Actor)	Kate Beckinsale	Kate Winslet	Sheryl Crow (Singer)
Which comedy has ______ playing an intimidating father who distrusts his daughter's new boyfriend?	Meet the Parents	Robert DeNiro (Actor)	Tommy Lee Jones	Kevin Bacon	Tom Petty (Singer)
What reality show features ______ hosting a nationwide singing contest?	American Idol	Ryan Seacrest (TV Personality)	Joel McHale	Jimmy Fallon	Tim Tebow (Athlete)
Which comic book company created superhero movies with ______ portraying a former Russian spy?	Marvel Entertainment	Scarlett Johansson (Actor)	Jessica Alba	Jennifer Love Hewitt	Carrie Underwood (Singer)
What Disney show features ______ as one of three supernatural siblings who compete to avoid becoming mortal?	The Wizards of Waverly Place	Selena Gomez (Actor)	Demi Lovato	Ashlee Simpson	Bristol Palin (One-News Wonder)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which movie has ______ playing a process server who witnessed the death of his marijuana dealer's boss?	Pineapple Express	Seth Rogen (Actor)	Jonah Hill	Adam Sandler	Lance Bass (Singer)
Which ensemble sitcom features ______ as the second wife of a well-off older man with two adult children?	Modern Family	Sofia Vergara (Actor/TV Personality)	Catherine Zeta-Jones	Nicole Kidman	Martina McBride (Singer)
Which cable station has ______ hosting a comedic, fake political news program?	Comedy Central	Stephen Colbert (Actor/TV Personality)	Bob Saget	Howie Mandel	Keith Urban (Singer)
Which movie has ______ playing a career-focused character who hires an immature, obnoxious woman as a surrogate mother?	Baby Mama	Tina Fey (Actor)	Winona Ryder	Christina Applegate	Shania Twain (Singer)
Which movie has ______ saying 'Life is like a box of chocolates'?	Forrest Gump	Tom Hanks (Actor)	Bill Murray	Alec Baldwin	Garth Brooks (Singer)
Which Disney movies have ______ playing a teenage basketball player who secretly wanted to dance and sing?	High School Musical	Zac Efron (Actor/Singer)	Jesse McCartney	Justin Bieber	Ryan Lochte (Athlete)

Question	Target Answer to Question	Target Name	Visually Similar Semantic Distractor	Visually Dissimilar Semantic Distractor	Unrelated Distractor
Which movie has ______ playing one of three groomsmen who cannot find the groom after the bachelor party?	The Hangover	Zach Galifianakis (Actor)	Ryan Dunn	Russell Brand	John Mayer (Singer)