Speeded Naming or Naming Speed? The Automatic Effect of Object Speed on Performance

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Abstract

In this paper we test the hypothesis that naming an object depicted in a picture, and reading aloud an object's name, are affected by the object's speed. We contend that the mental representations of everyday objects and situations include their speed, and that the latter influences behavior in instantaneous and systematic ways. An important corollary is that high-speed objects are named faster than low-speed objects despite the fact that object speed is irrelevant to the naming task at hand. The results of a series of 7 studies with pictures and words support these predictions.

Keywords: Implicit speed, automatic activation, picture naming, word reading

Everyday objects evoke mental constructs and dispositions beyond mere perception or recognition. These constructs are activated in a fast and automatic fashion, often outside of conscious awareness (Bargh, 1994; Higgins, 1996; Hassin, 2013). Arguably the best-known and most-researched property of objects is their valence. Valence is present not only with obviously threatening or appealing stimuli such as a snake or a piece of food, but a modicum of valence or “micro-valence” (Lebrecht et al., 2012) is present in such an innocuous object as your morning coffee mug. The prevalence of valence is easily understood considering its role in evolution, and its role in shaping online motivations, emotions, and decisions.

In the present study, we turn the spotlight to another high-level property, speed, which has largely been overlooked in the existing literature. We argue that the mental representations of everyday objects often include a value of speed, which can influence people’s actions in a systematic fashion. In a series of seven studies we show that object speed influences performance in such simple and instantaneous tasks as naming picture of these objects, or reading aloud their names. This influence is all the more impressive when one recognizes that object speed is irrelevant to the explicit task set at hand.

Speed is a continuous variable. Some objects are associated with no- or merely low-speed (what one might term, following Lebrecht et al., 2012, “micro-speed,” e.g., plant). Other objects prompt slow to moderate speed (e.g., turtle, snail), and still other objects evoke high velocity (e.g., airplane, train).

The relevant speed value is, of course, context-dependent. An airplane parking on the ground is likely to activate a different speed than one that is currently in flight.

The activation of an object's speed might be also vital for survival. A threatening attack dog is of extremely negative valence, yet the proverbial decision of fight or flight is resolved by the assessment of speed and proximity (Fanselow, 1994; Maren, 2007; Mobb et al., 2007). In the same manner, regardless of the affect associated with cars, the decision to cross or not cross a busy road should depend on speed and direction of movement – and an error can be very costly. It is partly for these reasons that movement and speed, subsumed under "activity," were found to be a fundamental dimension of meaning in the classic research by Osgood, Succi, and Tannenbaum (1957).

The idea that object speed may affect simple and early cognitive processing was inspired by two leading schools of thought in contemporary experimental psychology. Embodiment, or grounded cognition, holds that when "people perceive visual objects, simulations of potential actions become active in preparation for situated action" (Barsalou, 2008, p. 624). One way that words and pictures convey meaning is thus grounded in the bodily activity associated with them (e.g., Glenberg & Kaschak, 2002; Schubert, 2005; Williams, Huang, & Bargh, 2009). When one sees sharks, or the word "shark," an implication is that things can happen really fast and therefore speedy action might be needed.

A similar line of thinking originates from considering the multitudinous effects of priming (for recent reviews see Bargh et al., 2012; Hassin, 2013). In the most relevant line of research, Bargh and his colleagues have shown, for example, that priming old age leads to slower walking (Bargh, Chen, & Burrows, 1996; but see Doyen et al., 2012 for a different take on this effect). Building on these findings Cesario, Plaks, & Higgins (2006) have shown that this effect is motivational in nature: Participants who implicitly like older adults indeed walk more slowly following priming, whereas those who like them less actually walk faster. In another study, Matlock (2004) found that it took participants longer to semantically process a sentence entailing fictive motion (e.g., "The road *runs* through the valley") when this sentence followed a story involving slow motion (vs. one that implied fast motion).

Thus, both the priming and the embodiment accounts suggest a link between an object's speed and subsequent behaviors (e.g., Bargh, Chen, & Burrows, 1996; Barsalou, 2008). Note that both accounts distinguish between the stimulus that brings about the priming (or the simulation), and the process that it changes. To take just one example, Bargh and colleagues have primed the notion of slowness via the reading of words related to old age, and shown that this priming phase slowed participants' walking (see also Matlock, 2004).

But why wait? If we assume that the act of speeding cognition towards faster objects serves a function, then it makes sense to speed cognition as fast as one can. The hypothesis examined here, then, is that the effect of stimulus speed is inherent in processing to the extent that it affects the performance with respect to the stimulus itself. To test this hypothesis we examine the process of reading a word or naming a picture, hypothesizing that faster objects are processed more quickly than slower ones.

The Present Study

The latency of naming words and pictures is influenced by a wealth of well-known variables, including word frequency, word length, phonetic structure, orthographic neighborhood, age of acquisition, picture complexity, goodness of depiction, and name agreement (e.g., Balota et al., 2007; Bates et al., 2003; Szekely et al., 2004). Nevertheless, a relatively large portion of the variance in naming latency is still unexplained by these attributes. In the present study we suggest the variable of object speed as a potent predictor of word- and picture-naming latencies, even when one controls for all previously mentioned variables.

The hypothesis that we examine here is that the aforementioned low-level determinants are not the only systematic determinants of cognitive speed, and that high level features also influence this process. In the studies we conduct and report here the participants' task was to name objects depicted as pictures or to read them as words. The presented pictures and words were drawn from standardized, internationally recognized pools of stimuli (pictures: the International Picture Naming Project [IPNP, Szekely et al., 2004]; words: the English Lexicon Project [ELP Balota et al., 2007]). Three features of these pools of stimuli are noteworthy. The first refers to their sheer size. The ELP, for instance, includes more than 40,000 English words. Second, the pictures (and the words) transcend several categories, from household items to foods to natural phenomena. Third and perhaps most important, the data entail behavioral norms, notably mean latencies to name the pictures and the words. These behavioral data, too, are broadly based (e.g., latencies in the ELP are based on responses by over 400 people).

Of the large population of pictures (and words), we focused on the sub-category of vehicles. Our goal was to sample stimuli for which speed is almost invariably relevant, spanning a large range of values of speed. In Study 1 (IPNP pictures) and Study 4 (ELP words) our subjects rated the stimuli for speed. Subsequently, we correlated the mean latencies for naming available in the international norms with the rating of speed by our participants. Studies 2 and 5 looked at correlations between rated speed and speed of naming/reading in our laboratories, controlling for known lexical predictors. Study 3 further demonstrated the effect of object speed in a larger set of 275 IPNP pictures of common actions. Finally, in two dedicated experiments probing causality, Experiment 1 and Experiment 2, we manipulated the context of the objects, such that in one context the objects were faster than in another (e.g., a car driving uphill or downhill). This context manipulation allowed tight control over virtually all confounding variables, while testing a fully causal account.

Study 1

The stimuli presented in this study were pictures of vehicles drawn from the IPNP (Szekely et al., 2003, 2004). Mean latency norms to name each picture were also obtained from the IPNP. Independently, we collected (non-speeded) ratings of speed for each picture by a group of Israeli students. Does the time needed to name the stimulus – a task of picture recognition – depend on the speed inherent in the referent object?

Method

Participants. The participants were 44 Open University undergraduates (33 women; mean age 27). The participants rated the apparent speed of the objects depicted in each picture. All participants had normal or corrected-to-normal vision, and they received course credit.

We tested this relatively large group of 44 participants in order to produce reliable assessments of object speed. In subsequent (between-subjects) Studies 3 and 4, we similarly tested large groups of at least 40 participants to achieve the same goal. The precise number of participants depended on availability (via volunteer enrollment) prior to the study.

Apparatus and stimuli. We selected all 35 items in the IPNP category of vehicles. Because some items were stationary (e.g., slide), we used the 29 items depicting vehicles of locomotion (e.g., wheelchair, bicycle, motor car, rocket). For each picture, we recorded the mean latency to name the referent object that had been collected within the IPNP[1].

Pilot measurements: ratings of valence, threat, and arousal of pictures in Study1 and 2. A group of 42 Open University undergraduates (31 females; mean age 29), none of whom participated in the current studies, judged the pictures on valence, on threat, or on arousal. Each judge rated all randomly presented pictures in a different order on one of three Likert scales: 1 (*good*) to 7 (*bad*); 1 (*not threatening*) to 7 (*threatening*); 1 (*not exciting*) to 7 (*exciting*).

[1] All the pictures and RT norms can be viewed and downloaded from the IPNP site at http://crl.ucsd.edu/experiments/ipnp/

One item from Study1 (stroller #019) was missing due to technical reasons. Since the category of vehicles included two pictures of baby strollers, the pertinent missing values were subsequently replaced with those of the second stroller in the list (stroller#428).

Procedure. The participants were tested individually in a dimly lit room. Presented with a single picture on the computer screen, they judged the referent vehicle's speed on a 1 (*slow)* to 7 (*fast)* scale. The participants typed in their response on the keyboard, after which the next picture appeared. These ratings of speed were not timed. Each participant received the set of pictures in a random and different order.

Results and Discussion

A glimpse at Figure 1 reveals a remarkable association between the two independent sets of data. The Pearson correlation between the naming RTs and the average ratings of speed amounted to $r(27)=-.62$ ($p<.001$)[2]. In order to assess the unique contribution of speed to naming RT and to control residual shared variance with other known higher-order variables, we additionally correlated the ratings of speed with naming latency after partialing out the ratings of valence, threat, and arousal: $r(26)=-.62, p<.001$ after partialing out valence; $r(26)=-.63, p<.001$ after partialing out threat; and $r(26)=-.66, p<.001$ after partialing out arousal. Clearly, removing valence, threat, or arousal left the association of naming RT and object speed intact.

INSERT FIGURE 1 HERE.

What about other known determinants of recognition latency? When we included the lexical features provided by the IPNP (number of alternative names; percent name agreement[3]; length in syllables; length in characters;

[2] Performing the same analysis on all 35 items in the IPNP category, including the 6 non-vehicle stationary items (slide, tire, steering-wheel, wheel, seesaw, and swing) keeps the speed association significant at $r(33)=-.60$, $p<.001$.

[3] Measures the proportion of all valid trials on which participants produced the dominant target name.

frequency[4]; age of acquisition[5]; picture visual complexity[6]; Szekely et al., 2003), and three known semantic variables (valence, threat, and arousal; see pre-test) in a stepwise multiple regression, object speed proved an important predictor of naming latency. In fact, object speed (β=-.37, p=.006) and the number of alternative names (β=.60, p<.001) proved the only reliable predictors of naming performance. Interestingly, together these two variables explained over 65% of the variance in naming latency [F(2,26)=27.37, p<.0001 for adjusted R^2], whereas speed alone explained over 36% in an independent model, F(1,27)=16.72, p<.001.

Given the ongoing debate concerning the use of automatic regression methods (e.g., Thomson, 2001), we also performed a best-subset analysis of all possible regression models. In all studies we sorted the best models of all possible numbers of factors by the adjusted R^2, followed by Mallows C_p, in order to systematically assess the most predictive model.[7] The subsets analysis indicated there was a (six factor) model with higher adjusted R^2 (and lowest C_p), R^2 adjusted=70.7%, C_p=3, F(6,22)=12.27, p<.0001. This model included speed (β=-.29, p=.029) and also alternative names (β=.69, p<.0001), name agreement (β=.14, p=.27), arousal (β=.30, p=.022), threat (β=-.45, p=.035), and valence (β=.37, p=.54). See Table 1 for the correlation of each of the individual lexical predictors with naming latency.

In conclusion, ratings of object speed by Israeli participants reliably correlated with the time needed to recognize the same objects by American participants.

INSERT TABLE 1 HERE.

Study 2

[4] Frequency counts based on the CELEX Lexical database (Baayen, Piepenbrock, & Gulikers, 1995).

[5] Taken from published norms of the American version of the MacArthur Communicative Development Inventories (Fenson et al., 1994). This measure includes a three-point scale of parental assessments: 1 = word was acquired between 8 and 16 months; 2 = between 17 and 30 months; 3 = words that are not acquired in infancy (> 30 months).

[6] Estimates based on the size of the digitized JPEG stimuli picture files set at a resolution of 300 x 300 pixels.

[7] We used the models suggested by Minitab, v. 17.

In Study 2 we tested our hypothesis in a more powerful within-subject design in which the *same* group of participants performed *both* speeded naming of objects and non-speeded rating of the speed of those objects in separate blocks of presentations

Methods

Participants. The participants were 20 Open University undergraduates (15 women; mean age 26). All participants had normal or corrected-to-normal vision, and they received course credit. One participant whose responses were more than 50% invalid (multiple microphone failures and object misidentifications; see data analysis below) was omitted from the analysis.

In Studies 2 and 5 that entailed a single group of participants (performing both in ratings of speed and object naming), we collected data from ~20 participants. The precise number depended on enrollment prior to the study.

Apparatus and stimuli. The stimuli were the same set of pictures of vehicles used in Study 1. Two of the pictures were dropped because they have the same name in Hebrew [stroller(#19), wagon(#488)]. The set of 27 pictures was presented three times in a random fashion, making for 81 experimental trials in all. All the pictures were presented via a Dell computer and displayed on a 17-in. color monitor set at a resolution of 1,024 X 768 pixels (the resolution of the pictures was set at 300 X 300 pixels). The participants performed 8 practice trials with a set of non-vehicle objects.

Procedure. The participants were tested individually in a dimly lit room. Their first task was a speeded naming of the objects depicted in the pictures. Presented with a picture on the computer screen, the participant was asked to name it as quickly and accurately as possible by saying the name into the microphone headset (Teac HPX-8 brand). A DirectRT software (Version 2008.1.0.11) recorded the time until the participant begun to pronounce a response. Stimulus exposure was response- terminated. The interval between the participant's response and the appearance of the next stimulus was 500 ms.

The second task was a non-speeded rating of the same object depicted in the picture. The participants judged speed on a 1 (*slow)* to 7 (*fast)* scale. Each participant received the set of pictures in a different random order in the two tasks.

Data analysis. For the first speeded task, we used the criteria offered by Szekley et al. (2003) for classification of valid responses (e.g., removing verbalizations such as "that's a ball," hesitations, or non-codable names). In addition, responses shorter than 250 ms or longer than 2250 ms (2.8% of valid responses) were not analyzed. As performed by Szekley et al. (2003) the number of alternative names for each picture was determined by "number of types" (i.e., number of different names provided on valid trials, including the target name). Percent name agreement was defined as the proportion of all valid trials in which participants produced the *dominant* target name.

Results

Object speed and speed of naming. The correlation between the time needed to name the object and the rating of object speed amounted to an appreciable r(25)=-.44, (p=.022; see Table 2 for all correlations). In order to further control for shared residual variance of other semantic variables with speed, we correlated the ratings of speed with naming latency after partialing out ratings of valence, threat, or arousal (see Study1, pretest). While valence had a significant association with naming latency (see Table 2), this association seemed independent from the association of speed ratings, as the correlation of speed ratings with naming RTs remained highly reliable at r(24)=-.42, p=.034 after partialing out valence. Arousal and threat did not correlate with naming latency however, but similarly partialing out arousal or threat did not affect the association of speed with naming latency [r(24)=-.44,p=.025 after partialing out arousal; r(24)=-.47,p=.017 after partialing out threat]. Thus, it seems that the documented effects of speed cannot be attributed to these variables. In a stepwise multiple regression that included all available lexical features,[8] and the three semantic variables –valence, threat, and arousal, speed was selected as a significant predictor of naming latency in a three-factor model (β=-.25, p=.047) including name agreement, β=-.51,p=.001, and valence (β=.37,p=.012), adjusted R^2=51.9%, F(3,23)=10.37, p<.001. Speed alone explained 16% of the adjusted variance in an independent model, F(1,25)=5.92,p=.022.

Additionally, in the best possible subset analysis (for criteria, see Study1) speed was also included in the model with the highest adjusted R^2 =58.3%, F(5,21)=8.27, p<.001 (and the lowest C_p =2.1 of a five-factor model), β= -.15,p=.15, along with alternative names β=.64,p<.001, frequency β= -.21,p=.093, arousal β=-.33, p=.033 and valence β=.29,p=.058. Thus, although speed does not reach traditional levels of significance, both types of analyses provide evidence for its role in determining speed of action.

INSERT TABLE 2 HERE.

A multilevel within-participant analysis

Since in this study we collected in the laboratory RTs from individual participants, we could additionally conduct a more powerful multilevel analysis which incorporates inter participant variability. In this analysis, speed was similarly found a highly significant predictor of naming times[9], B=-26.12 (SE=5.91), t(502.2)=-4.42,p<.0001. The estimate represents a predicted acceleration rate of 26.12 ms in RT per single point in speed rating, and a cumulative acceleration of ~157ms of an item with a rating score of 7

[8] The lexical predictors used were based on the factors provided within the IPNP that were available in in Hebrew. These included: number of alternative names; percent name agreement; length in syllables; length in characters; frequency (Frost & Plaut, 2005); and IPNP picture visual complexity.

[9] The multilevel analysis included ratings of speed as a fixed covariate as well as a fixed intercept, using objects as a repeated measure. The analysis was performed in SPSS v18. We used a model of restricted maximum likelihood estimation, entailing compound symmetry as a repeated covariance type.

compared to an item with a rated speed of 1. In a multilevel analysis which included the predictors selected by the stepwise regression, speed was a reliable predictor of naming latency, B= -16.18 (SE=5.73), t(499.9)= -2.82, p<.01, along with valence and name agreement (p<.0001).

In another test of the effects of lexical features, we selected 5 of the fastest and 5 of the slowest rated pictures, matched on the three most contributing variables (alternative names, t(4)=.17 p=.87; frequency, t(4)=.61, p=.58; and agreement, t(4)=1.05, p=.35). A comparison between these two groups of stimuli showed that it took longer to name pictures of slow objects (M=1180, SD=144) than pictures of fast objects (M=1083,SD=163;t(19) = 3.01, p<.01; Cohen's d=0.67; 95% CI [0.44, 0.91]).

Discussion

The results of Studies 1 and 2 support the notion of activation of the higher-level property of speed when people recognize everyday objects. Crucially, object speed was never mentioned in the instructions of the naming task, nor was it an explicit part of the task description.

A possible reservation with respect to the results of Studies 1 and 2 is that speed plays a role only when speed is blatantly expressed. To address this concern, in Study 3 we examined stimuli that are not as clearly associated with speed or movement. We made use of the large category of pictures from the IPNP (Szekely et al., 2005) depicting people's actions. The category of actions includes 275 pictures of everyday behaviors (e.g., writing, tooth brushing, painting, fishing, drinking). Many of the stimuli that appear in these scenes move very slowly, at best. Nevertheless, if speed is a feature that is activated in an automatic fashion, one should still find an association between naming latency and subjective speed.

In Study 3, we used the tactic of Study 1: RT norms for naming each of the 275 pictures in the IPNP were pit against ratings of speed of the same objects obtained from a local group of Israeli participants.

Study 3

Methods

Participants. The participants were 44 Open University undergraduates (34 women; mean age 27). They rated the apparent speed of each object depicted in the picture. All participants had normal or corrected-to-normal vision, and they received course credit.

We tested this relatively large group of 44 participants in order to produce reliable assessments of object speed in this between-subjects design. The precise number of participants depended on availability (via volunteer enrollment) prior to the study.

Apparatus and stimuli. The stimuli were the 275 drawings of everyday actions included in the IPNP database. For each picture, we selected the mean latency to name the referent object from the IPNP norms (Szekely et al., 2005).

Pretest: ratings of valence, threat, and arousal. 45 Open University undergraduates (37 females; mean age 29), none of whom participated in the current or previous studies, judged the pictures on either valence, threat, or arousal. Each judge rated all 275 randomly presented pictures in two sessions separated by a break of ~30min in a different order on one of three Likert scales: 1 (*good*) to 7 (*bad*); 1 (*not threatening*) to 7 (*threatening*); 1 (*not exciting*) to 7 (*exciting*).

Procedure. The participants were tested individually in a dimly lit room. Presented with a single picture on the computer screen, they judged the referent's speed on a 1 (*slow)* to 7 (*fast)* scale. The participants typed their response on the computer keyboard. The ratings of speed were not timed. Each participant received the set of pictures in a random and different order. A short break separated the first and second halves of the stimuli.

Results and Discussion

We found an association between the time needed to name each picture, as it was obtained from the U.S. participants in the IPNP, and the ratings of each object's speed, given by Israeli participants. The correlation was relatively small, yet reliable at r(273)=-.14, p=.016. In order to further control for shared residual variance of these variables with speed, we correlated the ratings of speed with naming latency after partialing out ratings of valence, threat, or arousal (see pretest). Valence had a significant association with naming latency and was also correlated with speed ratings (see Table 3). Yet, this association seemed independent from the association of speed ratings, as the correlation of speed ratings with naming RTs increased to r(272)=-.19, p=.001 after partialing out valence. Similarly, partialing out threat, which was also correlated with speed ratings, or arousal, had a refining effect on the association of speed with naming latency: r(272)=-.20,p=.001 after partialing out threat; r(272)=-.16,p=.008 after partialing out arousal.

Notably, the contribution of object speed to picture recognition remained reliable (β=-.11, p=.008) in a stepwise multiple regression that included all available lexical, perceptual and semantic factors (Szekely et al., 2005)[10]. Along with speed, included in the stepwise solution were alternative names (β=.44, p<.0001), name agreement (β=-.33, p<.0001), visual complexity (β=.08, p=.042), and valence (β=.13, p=.002), R^2 adjusted = 58.7%,F(5,269)=78.75, p<.0001. The best-subset analysis (for criteria see Study 1) indicated that there was a model with a slightly higher adjusted R^2 =58. 8%, F(7,267)=55.91,p<.0001, C_p=5.2. Notably, this model included speed (β=-.10, p=.02) and six additional variables, alternative names (β=.43, p<.0001), name agreement (β=-.33, p<.0001), visual complexity (β=.08, p=.052), frequency (β=.08, p=.11), age of acquisition (β=.06, p=.24), and valence (β=.13, p=.002) , see Table 3 for all the correlations with naming latency. Note that the speed ratings effect was comparable in size with that of valence in this large pool of everyday actions. It seems that because speed was less

[10] The lexical predictors used were the same set of factors provided within the IPNP (Szekely et al., 2005). These included: number of alternative names; percent name agreement; length in syllables; length in characters; frequency; age of acquisition. The perceptual factor included were visual complexity, and ratings of valence, threat, and arousal (see pretest).

consequential for the tested actions, its effect was weaker yet present.

INSERT TABLE 3 HERE.

The results of Study 3 show that the variable of subjective speed is correlated with object naming in a wide variety of situations and actions. In Studies 1–3, naming performance was influenced by the task-irrelevant property of object speed. Would the same effect obtain for word reading? Studies 4 and 5 examined the effect of speed implied in the meaning of the word against the time needed to read that word.

Study 4 was a conceptual replication of Study1, except that here the stimuli were words denoting the same objects. The words along with their RT norms were drawn from the large database included in the English Lexicon Project (ELP, Balota et al., 2007). Ratings of the speed of the objects conveyed by the words were obtained from a local group of participants.

Study 4

Methods

Participants The participants were 43 Open University undergraduates (31 women; mean age 27). They rated the speed of the referent vehicles denoted by the words. All participants had normal or corrected-to-normal vision, and they received course credit.

We tested this relatively large group of 43 participants in order to produce reliable assessments of object speed in this between-subjects design. The precise number of participants depended on availability (via volunteer enrollment) prior to the study.

Apparatus and stimuli. The stimuli were the same set of vehicles used in Study 1. Because the words *unicycle, fire truck, and roller skate* do not have an RT norm in the ELP, we presented only 24 items with available RT norms for reading. For items with several equivocal dictionary translations in Hebrew, we presented all alternative names on the screen as describing the item to be rated.

Pilot measurements: ratings of valence, threat, and arousal of the words in Study 4 and 5. A group of 48 Open University undergraduates (36 females; mean age 31), none of whom participated in the current or previous studies, judged the Hebrew words on valence, threat, or arousal. Each judge rated all 42 randomly presented words (including alternative Hebrew translations of the vehicles) in a different order on one of three Likert scales: 1 (*good*) to 7 (*bad*); 1 (*not threatening*) to 7 (*threatening*); 1 (*not exciting*) to 7 (*exciting*). Since the Hebrew equivalent of a given English word can be translated into several alternative names of an object (e.g., either plane or airplane is a legitimate translation of airplane in Hebrew), the ratings of the (English) vehicle names in the pilot of Study 4 were calculated based on the mean rating of all its alternative Hebrew translations.

Procedure. The participants were tested individually in a dimly lit room. Presented with a single word, they judged the speed of the referent item on a 1 (*slow)* to 7 (*fast)* scale. The ratings of speed were not timed. Each participant received the set of words in a random and different order.

Results and Discussion

Figure 2 shows that the correlation between the independent sets of data is appreciable. The Pearson correlation amounted to $r(22)=-.55$ ($p=.005$). This result shows that the time needed to read a word is correlated with the speed of the object that the word names. In order to further control for any shared residual variance of these variables with speed in this study, we correlated the ratings of speed with naming latency after partialing out ratings of valence, threat, or arousal (see pretest). While threat was highly correlated with speed ratings and reading latency (see Table 4), the correlation of speed with reading latency remained reliable after partialing out threat, $r(21)=-.37$, $p=.041$. Similarly partialing out arousal or valence did not harm the association of speed ratings with reading times, $r(21)=-.60$, $p=.001$ after partialing out arousal; $r(21)=-.55$, $p=.003$ after partialing out valence. Thus, it seems that speed have a unique and independent contribution in predicting reading latency.

INSERT FIGURE 2 HERE.

The ELP reports the values of several lexical factors for each word. In a stepwise multiple regression including all available perceptual, semantic and lexical factors[11], speed turned out to be the strongest predictor of reading time (β= -.54, p=.001), along with pronunciation (β=-.52, p=.002), and syllables (β=.33, p=.03). These three variables explained over 55.5% of the variance in reading time, $F(3,20)=10.55$, $p<.001$ for adjusted R^2), whereas speed alone explained over 27% in an independent model, $F(1,22)=9.64$, $p=.005$.

A best possible subset analysis (for criteria see Study 1) indicated there was a (seven factor) model with higher R^2 adjusted=64 %, C_p= 6.3, $F(7,16)=6.85$, $p<.001$. Notably, it included speed (β=-.43, p=.05), along with frequency (β=.27,p=.13), pronunciation (β=-.53, p=.001), syllables (β=.34, p=.04), valence(β=.34, p=.06), threat (β=-.47, p=.03), and arousal (β=.21, p=.20), see Table 4 for the correlation with naming latency of the individual predictors.

INSERT TABLE 4 HERE.

Study 5

We deemed the results of Study 4 worthy of replication in a laboratory context. In Study 5 a group of participants performed both speeded reading and non-speeded rating of the same items for a more powerful within participant design. In addition, we also included alternative names for items that have alternative names in Hebrew (e.g., plane-airplane). This addition allows us to measure the correlation between the reading latency of two different words that denote the same object.

Methods

Participants. The participants were 18 Open University

[11] The lexical factors drawn from the ELP were: length in characters, HAL frequency, orthographic neighbors, number of syllables, and pronunciation naming accuracy (Balota et al., 2007). The semantic factors were the ratings of valence, threat, and arousal, see pretest.

undergraduates (14 women; mean age 23). All participants had normal or corrected-to-normal vision, and they received course credit.

In this study and Study 2 that entailed a single group of participants (performing both in ratings of speed and object naming), we collected data from ~20 participants. The precise number depended on enrollment prior to the study.

Apparatus and stimuli. The stimuli were the same set of vehicles from Study 1. This set was extended in the present study by including alternative names for the original pictures (e.g., the words "car" and "automobile" were both included). Consequently, the list of stimuli included 42 words. The set of 42 words was presented twice in a random fashion. All the words were presented via a Dell computer and displayed on a 17-in. monitor set at a resolution of 1,024 X 768 pixels. The words were presented in black, in bold Ariel font, size 20, on the white background of the screen.

Procedure. The participants were tested individually in a dimly lit room. The first task for the participants was speeded reading of the words. Presented with a word on the computer screen, the participant was asked to read it as quickly and accurately as possible by saying its name out loud into the microphone headset (Teac HPX-8 brand). A DirectRT software (Version 2008.1.0.11) recorded the time until participants began to pronounce a response. Stimulus exposure was response- terminated. The interval between response and the appearance of the next stimulus was 1000 ms.

The second task was non-speeded rating of the speed of the object depicted by the word. The participants judged speed on a 1 (*slow)* to 7 (*fast)* scale. Each participant received the set of words in a different random order.

Data analysis. In the speeded task, correctly articulated responses shorter than 1500 ms and longer than 250 ms were analyzed (97.1% of the responses; including all responses leaves the RT-rating correlation significant at .34). Overall, invalid pronunciations were rare (1.3% on average); however, one item, Zeppelin, was inaccurately articulated 14% of the time and was removed from the analysis.

In the comparison of alternative name latencies, the items were 10 pairs with an alternative name in Hebrew (e.g., helicopter-chopper; stimuli appear in Appendix A). One outlier (car-automobile) was removed from the analysis because its frequency scores were above 3 standard deviations of the frequency mean (which spuriously generated a correlation in frequency scores – r(9)=.70,p=.016 and r(8)=-.25, p=.48 –after its removal). The inclusion of this item did not affect the alternative names RT-RT correlation [r(9)=.82,p=.001], or the speed ratings-ratings correlation [r(9)=.90,p<.0001].

Results

The correlation between reading time and judgment of speed was r(39)=-.41 (p=.008). Performing the same calculation on the original set of 29 items from Study 1 yielded a correlation of r(27)=-.44, p=.017. In order to further control for shared residual variance of these variables with speed in this study, we correlated the ratings of speed with naming latency after partialing out ratings of valence, threat, or arousal (see Study4 pretest). While threat and arousal were correlated with speed ratings (see Table 5 note), this association seemed independent from the association of speed ratings, as the correlation of speed ratings with reading RTs remained highly reliable [r(38)= -.41, p=.009] after partialing out threat; or arousal [r(38)=-.45,p,=.003]. Similarly partialing out valence did not reduce the association of speed ratings with reading times [r(38)=-.44,p=.004].

We further obtained several lexical features of the Hebrew words including length, syllables, frequency (Frost & Plaut, 2005), pronunciation and semantic factors via ratings of valence, threat, and arousal (see Study4 pretest). In a stepwise multiple regression, only frequency (β=-.41, p=.005) and object speed (β=-.30, p=.38) were found to be reliable predictors of reading time. Together, these two variables explained 28.8% of the variance (adjusted R^2;

F(2,38)=9.1, p=.001).

A best possible subset analysis (for criteria see Study 1) pointed to a different four-factor model with the highest adjusted R^2 and lowest Mallows $c_{p.}$ Importantly, it included speed as a reliable predictor of reading latency (β= -.46, p=.007) along with frequency (β=-. 29, p=.062), arousal (β=.25, p=.12), and valence (β=.23, p=.13), R^2 adjusted =32.1%, F(4,36)=5.73,p=.001, C_p=2.7 (see Table 5 for the correlation with naming latency of the individual predictors). In an independent model speed alone explains 15% of the adjusted variance.

INSERT TABLE 5 HERE

A multilevel within-participant analysis

In a multilevel analysis, incorporating individual participant variance, speed was similarly found to be a highly reliable predictor of those swift reading responses, B= -10.51 (SE=2.05), t(640.0)=-5.12, p<.0001 (for criteria see Study2). Similarly, in a multilevel analysis which includes the predictors selected by the stepwise model, speed was also found a reliable predictor of naming latency, B= -7.93 (SE=2.07), t(639.1)= -3.84, p=.0001, along with frequency, B=-1.46 (SE=0.27), t(636.2)=-5.39, p<.0001 (for criteria see study 2).

In another test of the influence of lexical factors, we selected matched subsets of 15 words each, denoting objects that were rated as fastest and slowest, respectively. The items were matched on length [t(14)=0, p=1] and average frequency [t(14)=0.9, p=.38]. The difference in reading time between the matched slow items (M= 616, SD=80) and fast items (M=584,SD=83) remained appreciable in this analysis too, t(17) = 4.65. p<.001; Cohen's d= 1.10; 95% CI [0.84,1.35]. A comparable difference was obtained with the 5 matched picture pairs that were used in Study 2, with 583 ms (SD = 94) for the 5 fast words, and 623 ms (SD = 119) for the slow words, t(17)=2.44, p=.026; Cohen's d= 0.58; 95% CI [0.32,0.83].

The addition of alternative names allows an interesting comparison between the reading times of two words that denote that same object. Since these words denote the same object, there is, of course, a strong correlation between judgments of speed [$r(8) = .90$, $p = .0001$]. Importantly, however, in our sample there is no correlation in the lexical factors of the words (length, $r(8)=-.08$, $p=.82$; syllables, $r(8)=-.14$, $p=.70$; frequency, $r(8)=-.25$, $p=.48$; or pronunciation, $r(8)=-.15$,$p=.67$). Crucially, even with no clear lexical similarity, there is still a remarkable correlation between the reading times of alternative names, $r(8)=.76$, $p=.01$ (see Figure 3). This item-specific correlation, in the absence of correlation in the lexical factors, is a powerful demonstration of the role of semantic factors, and particularly object speed which is predominantly relevant in the category of vehicles.

INSERT FIGURE 3 HERE

Experiments on Causation

The results of Studies 1–5 are systematic, but they are correlational in nature; the speed of objects was never manipulated. The following Experiments 1 and 2 test the causal claim we made in the introduction by manipulating speed. We presented each object twice. In one context, the to-be-named object was presented in a “slow” situation, whereas in a second context the same object was presented in a “fast” situation. We hypothesize that the “faster” objects will be named faster than the “slower” objects, although the objects are the same. To reduce effects of task sets, the instructions to these experiments did not mention speed of response (although we did measure latency, of course).

Experiment 1

Twenty pictures of objects were presented in settings that implied slow or fast motion. For example, the same car appeared once on an upward slope and once on a downward slope (see examples in Figure 4). Again, the task was to name the object (i.e., to say “car” in both cases).

Methods

Participants. Forty-six students (34 females; mean age 29) from the Open University performed the experiment for course credit. In the absence of prior information, in context Experiments 1-2, we collected data in multiplies of ~20 participants. The precise number depended on prior enrollment.

Apparatus stimuli and design. There were 10 "fast" and 10 "slow" pictures of the same 10 items. The pictures were drawn from the IPNP; we merely altered the context to create impressions of "fast" and "slow" movement (see Figure 4 and Appendix B). We randomly selected 5 "fast" pictures and their corresponding "slow" pictures to make one block of 10 objects. The remaining 10 stimuli comprised the other block. The stimuli within each block were randomly intermixed. Each stimulus in each block was presented 5 times. Thus, the resulting block has 50 trials. There was a break of one minute between the two blocks. The apparatus was the same as in Study 2.

Procedure. The participants were asked to name the object in the picture into a microphone headset (Teac HPX-8 brand). Notably, participants were not instructed to be fast. A DirectRT software (Version 2008.1.0.11) recorded the time until the participant began to pronounce a response. Stimulus exposure was response- terminated. The interval between the participant's response and the appearance of the next stimulus was 2000 ms.

Data analysis. Responses were analyzed using the same criteria as in Study 2. If one member of the slow/fast-context pair was removed by these criteria, we removed its counterpart to allow for a valid comparison in averaging RTs.

INSERT FIGURE 4 HERE.

Results and Discussion

As hypothesized, mean naming latency for the same set of objects was longer in a context suggesting slow movement than in a context suggesting fast movement(see Figure 5). The respective means were 1053 (*SD*=172) and 1030 (*SD* =162) ms, t(45)=3.26,p=.002; Cohen's d=0.48; 95% CI [0.32,0.65].

INSERT FIGURE 5 HERE.

To examine whether the learning of the task and its structure makes a difference, we compared the first presentations of an object as "slow" and "fast." The effect was nominally bigger, amounting to 50 ms [t(1,45)=2.25,p=.03]. Considering the remaining data (i.e., repetitions 2–5), object speed again made a difference. The speedier context yielded an advantage of 17 ms in naming latency [t(45)=2.38,p=.022].

In sum, manipulating object speed in Experiment 1 yielded results that were qualitatively the same as those obtained in Studies 1-5: Objects with a faster (implied) motion were named more quickly. In the next and final experiment our goal was to replicate the results of Experiment 1 with an extended set of objects.

Experiment 2

Methods

Participants. Sixty participants from the Open University (47 females; mean age 28) participated in this experiment for course credit. In context Experiments 1-2 we collected data in multiplies of ~20 participants. The precise number depended on prior enrollment.

Apparatus stimuli and design. The design, apparatus, and stimuli were similar to those of Experiment 1, with the following exceptions. First, we avoided repeated presentations of items; a given item was depicted only once as "slow" and once as "fast." Second, we presented a larger set of items, drawn, again, from the IPNP. There were 36 pictures, 18 "slow" ones and their 18 "fast" counterparts (see Appendix C). In all other respects the procedures followed those of Experiment 1.

Manipulation check: context speed judgment. 15 Open University undergraduates (9 females; mean age 28), performed a forced choice judgment on the speed of the picture pairs. Each judge rated all 18 randomly presented pairs in a different order and was requested to select the fastest of each pair of pictures. The location of the picture contexts on the screen (left/right) was also randomly presented.

Results and Discussion

Replicating the results of Experiment 1, “faster” objects were named more quickly than “slower” objects. The mean latencies were 1294 (*SD*=214) and 1266 (*SD*=193) ms, respectively. The difference of 29 ms in favor of the “fast” version of the same object was significant, t(1,59)=2.07,p=.043; Cohen’s d=0.27; 95% CI [0.11,0.43].

In order to establish that participants tend to perceive our designated contexts as slower and faster, we asked an independent group of judges to choose which of the contexts is faster in each pair (see manipulation check above). 16 out of 18 of our “fast” stimuli were rated as faster by more than 80% of judges (p≤.018 of the binomial test, mean 89.6% of participants), one item (airplane) was rated as such by only 60% of participants (p=.30), and another (row) by 33% (p=.15). Clearly, our fast and slow categories are explicitly recognized as such by the majority of participants. Nonetheless, if one removes the less distinctive items (airplane and row) the effect is augmented slightly to 31ms (p=.04) in Experiment2, and to 27ms (p=.002) in Experiment1.

Collectively, the results of Experiment 2 (like the results of Experiment 1) rule out stimulus-specific explanations. Presenting the *same* object once as “fast” and once as “slow” serves as a radical control for virtually all confounding variables, especially those that refer to object-specific properties (including semantic and linguistic features).

Conclusion

In the seven studies we found that object speed — irrespective of the explicit task set – influenced performance such that “fast-moving” objects were named faster than “slow-moving” objects. This difference was even observed for the *same* objects in “fast” and “slow” contexts. These results suggest that people are disposed to act swiftly with speedy objects, regardless of whether swift action is explicitly demanded by the task or not.

The effect documented here is instantaneous: It is caused by object speed, and it affects the naming/reading of that same object’s picture/name. Unlike the lexical features that affect reading/naming times, speed is probably a high-level semantic feature. As such, it should not be stored in the lexicon.

Speed turned out to be a highly reliable predictor of naming latency, at times with higher (or comparable) effect sizes than the well-established higher order variable of valence (and threat) (see, e.g., Chen, & Bargh, 1999; Algom, Chajut, & Lev,2004). Valence or threat correlated with naming latency in all studies. While most of our studies involved the sampling of vehicles of locomotion, it is noteworthy that in Study 3, which sampled common everyday objects with little movement, speed and valence carried comparable effect sizes. Notably, the effects of speed and valence were independent, and they remained equally strong (or were even augmented) after clearing of the shared variance. The importance of valence is easily understood considering its role in evolution, and its role in shaping online motivation, emotions, and decisions. The activation of object speed can be vital for survival as the proverbial decision to fight or flight is often resolved by the assessment of speed and proximity (Fanselow, 1994; Maren, 2007; Mobb et al., 2007). Our study revealed for the first time the higher order variable of speed as a strong predictor of reading and naming latency in the simplest of tasks.

These results establish a novel phenomenon, but they do not shed much light on the underlying process. It seems to us likely that once semantic understanding is reached, it can act swiftly to affect online processing. One possible way in which this can be achieved is through embodied/grounded cognition. According to Barsalou (2008, p. 633), “As people comprehend a text, they construct simulations to represent its perceptual, motor, and affective content. Simulations appear central to the representation of meaning." These stimulations, in turn, affect behavior, broadly defined, and hence may affect the performance in our tasks as well.

The influence of mental simulations and top-down cognitive expectations are easily detected when considering moving objects. In the phenomenon termed "representational momentum" (Freyd and Finke, 1984), people often view the halt position of a moving object as lying further away along its trajectory than it really is. Although representational momentum typically involves movement (implicit and explicit), it may also play a role in generating expectations and simulations with still pictures of objects which possess or imply movement. In a noteworthy observation with still pictures entailing implied motion (very similar to those used in our study), it was shown that the pictures induced activation of brain regions associated with the processing of active visual motion (i.e., the medial temporal/medial superior temporal cortex-- MT/MST, Kourtzi & Kanwisher, 2000).

The present results can also be understood as an online example of priming. A remarkable aspect of priming is the access it affords to unconscious or implicit information stored in the cognitive system. Our results document the effect of priming in the simplest of tasks. In an often-cited study, Bargh et al. (1996) recorded sluggish walking after priming with elderly stereotypes. In another study, reading stories entailing slow motion induced slower decisions of fictive motion sentences (Matlock, 2004). Our results go beyond the studies of Bargh, Matlock, and others in identifying object speed as an important property of perception of objects that is instantaneously processed to influence performance with the primed-stimulus itself.

Context Experiments 1 and 2 teach us one more thing about the underlying process. The documented effects of object speed cannot be attributed solely to long-term semantic knowledge. As these experiments show, at least in naming pictures, the context quickly changed the implied speed, and with it the speed of naming the pictures. This seems consistent with the idea that unconscious, automatic processes have effects that are far more pervasive than the modal view holds (Hassin, 2013). This idea of instantaneous automatic integration is consistent with recent findings on non-conscious information integration (Mudrik et al., 2011; Sklar et al., 2012).

Our study also invites a brief look at the so called "flash lag" effect (MacKay, 1958; Nijhawan, 1994). The cognitive system perceives a moving object aligned with a flashed still object as displaced further along his trajectory than it really is. One of the explanations offered is that the brain adjusts the position of moving objects to account for the lag time it takes for it to reach consciousness (e.g., Nijhawan, 1994; Khurana and Nijhawan, 1995). In the tenth of a second it takes the brain to perceive an object, the object has already moved, and the brain adjusts for that in the representation conveyed to consciousness. Another explanation offers that moving objects are perceived faster than flashed objects (e.g., Baldo and Klein, 1995; Whitney & Murakami, 1998; Purushothaman et al., 1998). Both of these explanations contend that moving objects are subject to unique processing in the visual system, making them an important feature to tag early. Our results indicate that this early unique processing may extend to still pictures and words that carry information on movement and speed.

Let us conclude with a pragmatic caveat. Current experimentation in cognitive and social psychology is largely based on speeded responses. Given the present results, investigators should watch out for possible confounding of reaction times by the irrelevant variable of the implicit speed inherent in the presented stimuli.

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Tables

Table1

Correlation Coefficients of the Predictors Used in Study 1 with Naming Latency

Predictor	Correlation
Speed Rating	-.62***
Alternative Names	.75***
Name Agreement	-.29
Syllables	.03
Characters	.05
CELEX Frequency	-.29
Age of Acquisition	.31
Visual Complexity	-.09
Valence Rating	.11
Threat Rating	-.005
Arousal Rating	.28

Note. Lexical predictors were drawn from the IPNP. None of these predictors correlated with ratings of object speed ($p>.05$, multiple comparisons Bonferroni corrected).
***$p\leq.001$.

Table2

Correlation Coefficients of the Predictors Used in Study 2 with Naming Latency.

Predictor	Correlation
Speed Rating	-.44*
Alternative Names	.59***
Name Agreement	-.59***

Syllables	.01
Characters	.03
Frequency (Frost & Plaut, 2005)	-.42*
Visual Complexity	.15
Valence Rating	.43*
Threat Rating	.21
Arousal Rating	-.01

Note. The lexical predictors were calculated based on the Hebrew norms of the participants' dominant response. Picture visual complexity was drawn from the IPNP. None of these predictors correlated with ratings of object speed ($p>.05$, Bonferroni corrected).
*$p<.05$. ***$p\leq.001$.

Table3

Correlation Coefficients of the Predictors Used in Study 3 with Naming Latency

Predictor	Correlation
Speed Rating	-.14*
Alternative Names	.72***
Name Agreement	-.71***
Syllables	.12*
Characters	.13*

CELEX Frequency	.05
Age of Acquisition	.15*
Visual Complexity	.16**
Valence Ratings	.16**
Threat Ratings	.10
Arousal Ratings	.09

Note: Lexical predictors were drawn from the IPNP. Ratings of threat and valence tended to correlate with ratings of speed (r=.36; r=.25 respectively, p<.001). However, clearing the shared variance actually increased the partial correlation of speed with naming latency (r=-.20, p<.001) after partialing out threat; or valence (r= -.19,p,<.001). None of the remaining predictors correlated with the ratings of object speed (p>.05, Bonferroni corrected).
*p<.05. **p<.01. ***p≤.001.

Table4

Correlation Coefficients of the Predictors Used in Study 4 with Reading Latency

Predictor	**Correlation**
Speed Rating	-.55**
Pronunciation Accuracy	-.49*
HAL Frequency	-.29
Orthographic Neighbors	-.28
Length (Characters)	.26
Syllables	.17
Valence Ratings	.16
Threat Ratings	-.49*

Arousal Ratings	-.06

Note. Lexical predictors were drawn from the ELP. Threat ratings tended to correlate with speed ratings (r=.60, p=.002). Nonetheless, speed remained a reliable predictor after partialing out the shared variance (r=-.37, p=.041). None of the remaining predictors correlated with the ratings of object speed (p>.05, Bonferroni corrected).
*p<.05. **p<.01.

Table5

Correlation Coefficients of the Predictors Used in Study 5 with Reading Latency

Predictor	**Correlation**
Speed Rating	-.41**
Pronunciation Accuracy	-.20
Frequency (Frost &Plaut, 2005)	-.49***
Length (Characters)	.15
Syllables	.04
Valence Ratings	.28
Threat Ratings	-.17
Arousal Ratings	-.02

Note. Lexical predictors were calculated based on the Hebrew norms. Ratings of threat and

arousal tended to correlate with ratings of speed (r=.68; r=.47 respectively, p≤.01). Nonetheless, speed remained a reliable predictor after partialing out the shared variance with threat (r=-.41, p<.01) or arousal (r= -.45,p,<.01). None of the remaining predictors correlated with the ratings of object speed (p>.05, Bonferroni corrected).
**p<.01. ***p≤.001.

Figures

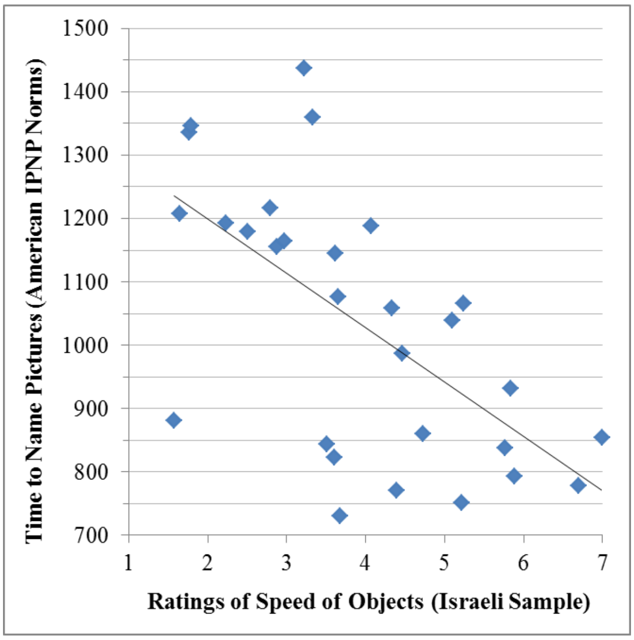


Figure 1. Naming latencies to pictures of vehicles from the IPNP norms, plotted

against ratings of speed of the same objects by a group of Israeli participants.

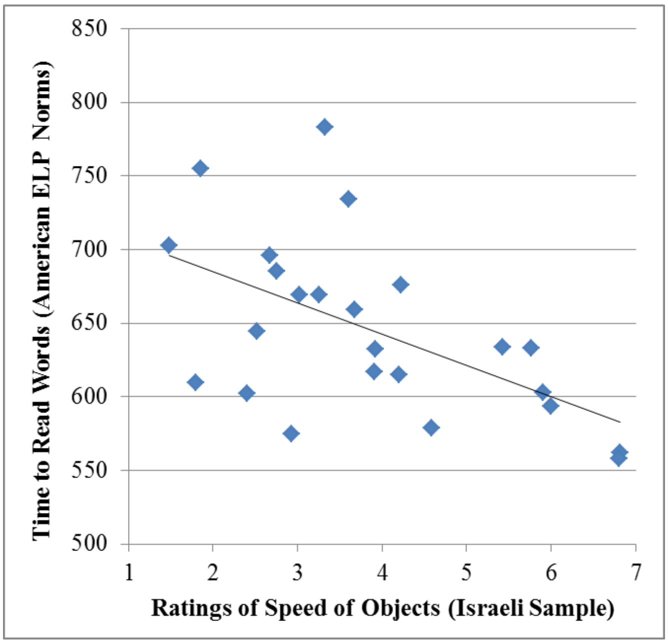


Figure 2. Reading latencies for words (drawn from the ELP norms), plotted against the ratings of speed for the named objects by an independent group of local participants.

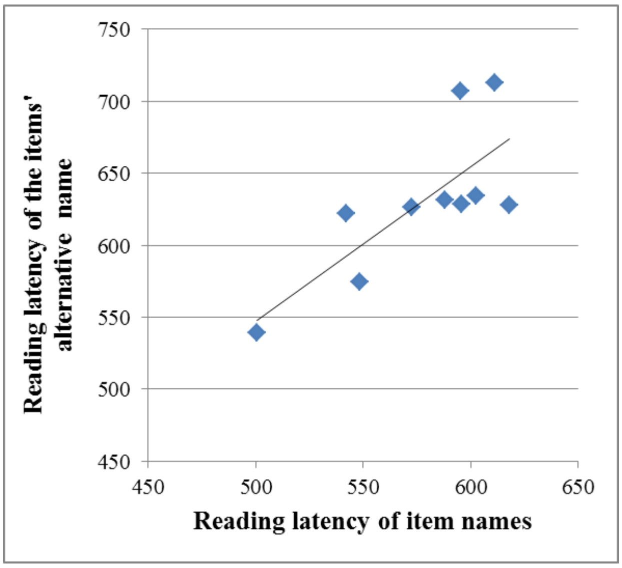
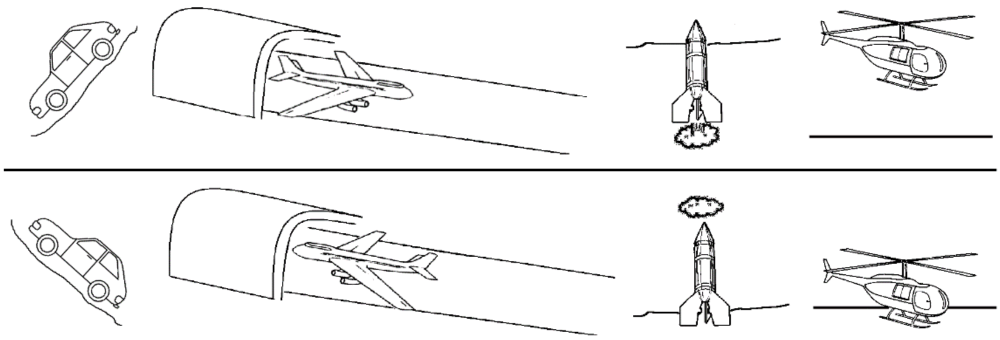


Figure 3. Reading latencies of individual items plotted against the latencies of each item's alternative name (e.g., plane-airplane; rocket-missile)



A sample of the stimuli used in Experiments 1 and 2. Each object is *Figure 4.* presented once in a “fast” context (upper panel) and once in a “slower” context (lower panel). The pictures, drawn from the IPNP, were modified slightly in order to create the different contexts.

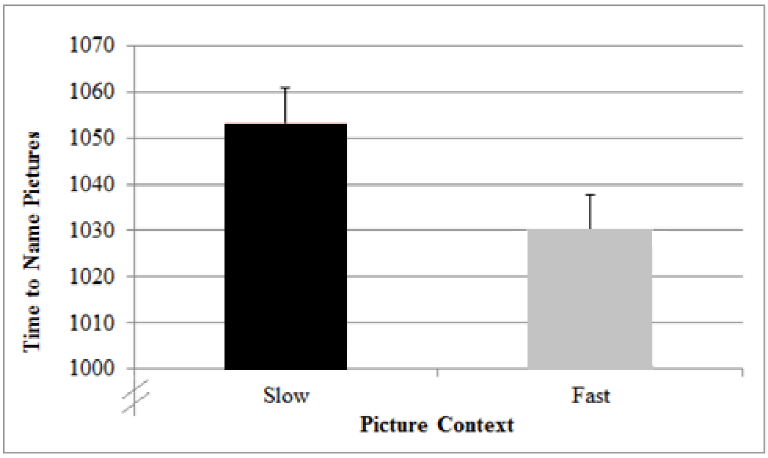


Figure 5. Mean RT to name the same 10 objects in a context suggesting impression of slow motion and in a context suggesting impression of fast motion. The bars depict one standard error around the mean.

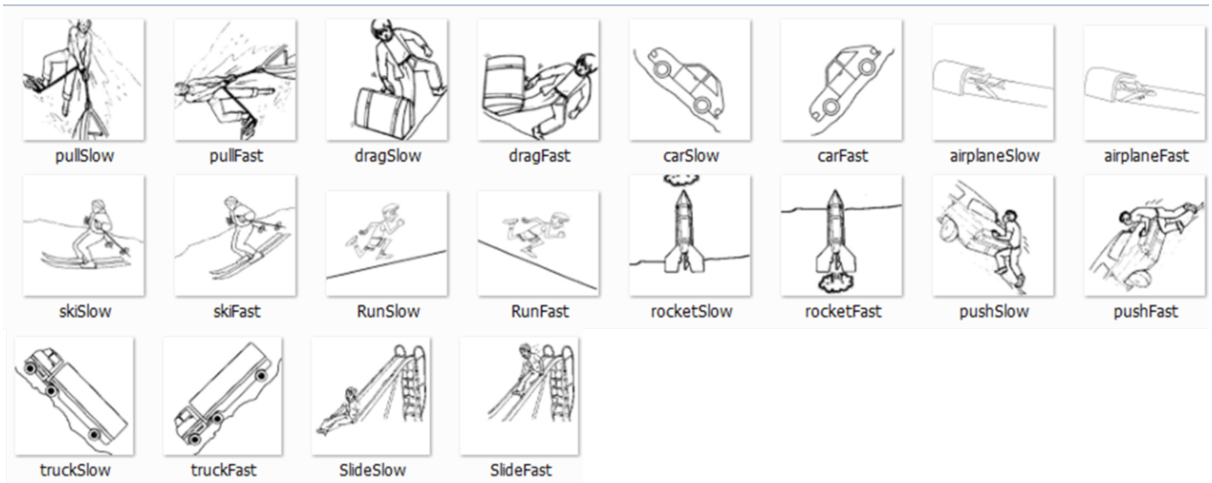
Appendix A

Alternative name pairs presented in Study 5

Name (English)	Alternative Name (English)	Name (Hebrew)	Alternative Name (Hebrew)
Chopper	Helicopter	מסוק	הליקופטר
Plane	Airplane	מטוס	אווירון
Rocket	Missile	טיל	רקטה
Sailboat	Sails	סירת מפרש	מפרשית
Stroller	Baby wagon	עגלה	עגלת תינוק
Trailer	W agon	קרון	כרכרה
Fire truck	Fire fighter carrier	כבאית	מכבה אש
Ship	Vessel	אוניה	ספינה
Roller skate	Skates	גלגיליות	סקטים
Boat	Canoe	סירה	קאנו

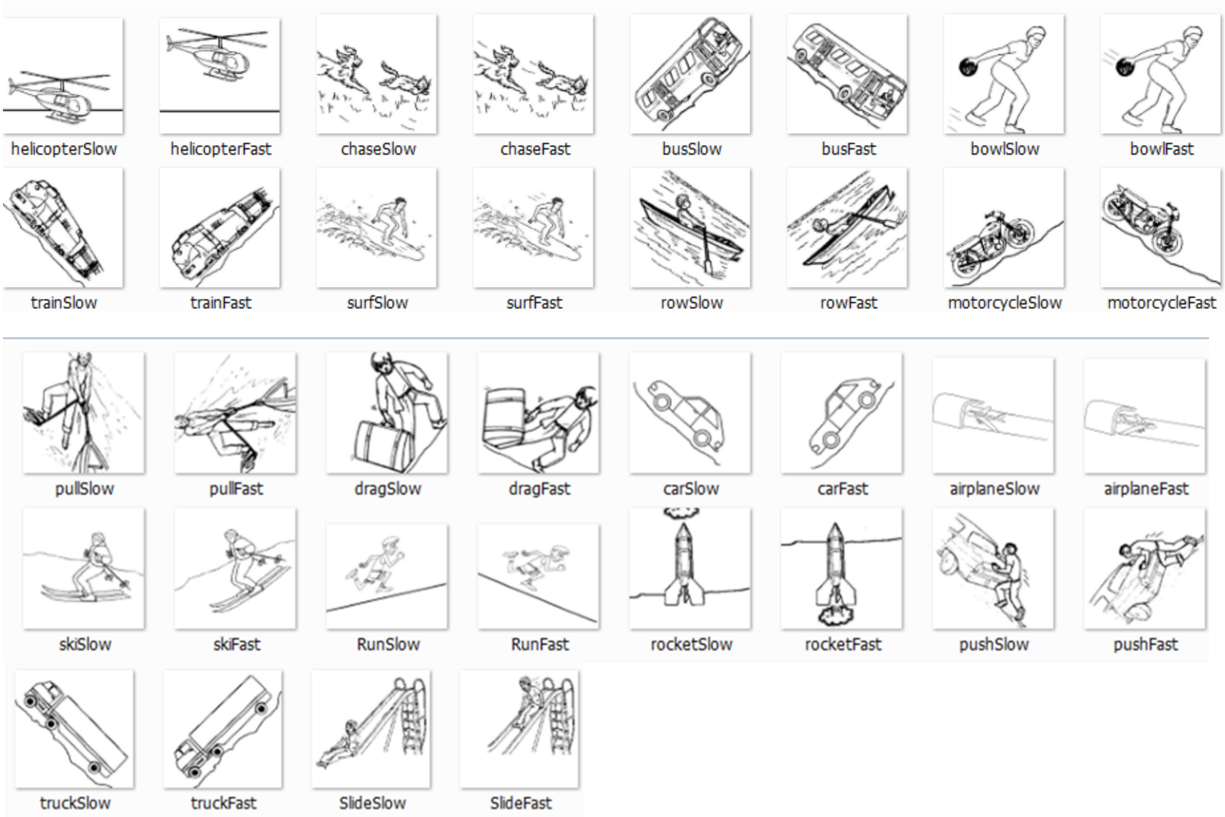
Appendix B

Stimuli presented in Experiment 1



Appendix C

Stimuli presented in Experiment 2


helicopterSlow
helicopterFast
chaseSlow
chaseFast
busSlow
busFast
bowlSlow
bowlFast
trainSlow
trainFast
surfSlow
surfFast
rowSlow
rowFast
motorcycleSlow
motorcycleFast
pullSlow
pullFast
dragSlow
dragFast
carSlow
carFast
airplaneSlow
airplaneFast
skiSlow
skiFast
RunSlow
RunFast
rocketSlow
rocketFast
pushSlow
pushFast
truckSlow
truckFast
SlideSlow
SlideFast