



Age of Acquisition (AoA) effect in monolingual Russian speakers and bilingual Russian (L1) - English (L2) speakers in a free recall task

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11 **Age of Acquisition (AoA) effect in monolingual Russian speakers and**
12 **bilingual Russian (L1) - English (L2) speakers in a free recall task**
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26 pictures and picture names
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38 Running head: AoA in Free Recall in Russian
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Age of Acquisition (AoA) effect in monolingual Russian speakers and bilingual Russian (L1) - English (L2) speakers in a free recall task

Abstract

AoA is a unique psycholinguistic variable because of its link to the semantic architecture of the mental lexicon (e.g., Brysbaert, Wijnendaele & de Deyne, 2000). The role of AoA on free recall has been examined in English (Coltheart & Winograd, 1986; Dewhurst, Hitch & Barry, 1998) and recently in Turkish (Raman, Raman, Ikier et al, under review) with contradictory outcomes. While an overall advantage was found for late acquired items in English, the contrary was reported in Turkish. Furthermore, this effect appeared to be modulated by frequency and whether items were presented in pure or mixed lists. The present study extends Raman et al study to monolingual Russian and bilingual Russian (L1) – English (L2) speakers in order to understand the extent to which AoA affects free recall. One interesting aspect of Russian writing system is that it consists of Cyrillic and Roman letters, hence creating a shared orthographic medium in Russian-English bilinguals. Participants were allocated to either picture or word condition and subsequently to either pure list or mixed list condition. Both monolingual Russian (N=42) and bilingual (N=40) Russian (L1) – English (L2) data show a robust main effect for AoA in free recall irrespective of list type for words and for pictures and no significant interactions. These findings are contrary to what has been reported in the literature for monolingual English speakers (Dewhurst et al, 1998) but in line with findings for Turkish (Raman et al, under review) and will be discussed within the monolingual and bilingual theoretical frameworks.

Key words: Age of Acquisition; monolingual Russian and bilingual Russian-English; free recall; pictures and picture names; bilingual memory

Introduction

The past 40 years has been marked by a rapid growth of studies focused on understanding the role of AoA on lexical and semantic processes as well as why this is the case. The first study on AoA was conducted by Rochford and Williams (1962) who found that the age at which children were able to name pictures correctly was correlated with a proportion of aphasic patients with who were also able to successfully name the same pictures. Carroll and White (1973) asked 20 adult participants to indicate an age when they believed they learned each word given using an 8-point rating scale (1 = age of 2-3 years to 8 = 14 years and older). The list of words was controlled for frequency effect. A significant difference was reported between words which were reported to be learnt earlier in comparison to those learnt later in life. On the contrary, there was no frequency effect. It was assumed that the age at which the word was learned has an influence on naming latency, and that word frequency rather has been incidentally associated with naming latency. Carroll and White (1973) concluded that ‘memories for words, and possibly other items, are stored according to a chronological dimension rather than a frequency dimension’ (pp. 91-92). This led to a number of questions and debates around the subject of AoA, such as the relationship between AoA and frequency. Questions were also raised as to whether AoA reflected cumulative frequency. Various theoretical explanations were proposed to explain the AoA phenomenon including a proposition that earlier acquired words are more accessible for retrieval due to their organisation in deeper levels of cortical representation than words acquired later (see Johnston and Barry, 2006 for an overview). It was suggested that early acquired words are in a privileged position because they are represented bilaterally in the brain when late acquired words mostly represented in the cortical area responsible for speech. However this theoretical account have been confidently dismissed by a number of studies that failed to show any cortical asymmetry for early acquired or late acquired words (e.g. Boles, Rogers and Wymer, 1982; Ellis and Young, 1977).

Subsequent studies on AoA led to its acceptance as an influential variable that had to be taken in consideration in lexical processing (e.g. Gilhooly and Logie, 1980; Gilhooly and Logie, 1981; Gilhooly and Watson, 1981). Gilhooly and colleagues employed word recognition, word naming and memory tasks to explore AoA effects as a secondary variable. Morrison, Ellis and Quinlan (1992) replicated Carroll and White’s (1973) study and confirmed that AoA but not word frequency affects picture naming. The same result was later reported for word naming

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3 (Morrison and Ellis, 1995). However it was not until Morrison and Ellis (1995) claimed the
4 significance of AoA as an influential variable more so than frequency that led to the significant
5 research in AoA.
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8 9 *Theoretical Accounts of AoA*

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11 An increased interest in the AoA effect led to the development of theoretical
12 consideration that generated the following questions: What is the mechanism responsible for the
13 emergence of the AoA effect? What is its locus in the lexico-semantic system?
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17 One of the early theoretical assumptions came from Brown and Watson (1987) who
18 suggested that early acquired words are phonologically more complete in the mental lexicon
19 than late acquired words. For late acquired words ‘only minimal information is stored explicitly’
20 (p. 215) which can be explained by a limited storage capacity of memory. Hence, early acquired
21 words can be accessed quicker when produced for naming. However the phonological
22 completeness hypothesis faced difficulties explaining the mechanisms of existence of the AoA
23 effect in lexical decision, semantic priming and face recognition tasks (see Johnston and Barry,
24 2006 for a review). A direct test of the phonological completeness hypothesis was conducted by
25 Monaghan and Ellis (2002a) who assumed that if early acquired words were phonologically
26 more complete than late acquired words then it would be more difficult to segment them. The
27 authors tested three conditions of phonological segmentation in a deletion task, that is,
28 participants were required to delete either a phoneme (e.g FROG= delete initial phoneme
29 >ROG), onset (e.g. SPOON = delete onset >OON) or first syllable (e.g. HAVOC = delete first
30 syllable >VOC) deletion. In contradiction to the phonological completeness hypothesis no
31 reliable differences were found between early and late acquired words.
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43 One explanation that came about as a consideration of the locus of the AoA effect was
44 the semantic hypothesis (Brysbaert, Wijnendaele, and de Deyne, 2000). Most authors have
45 explained AoA effects, particularly in word naming tasks, as having a lexical locus of origin not
46 taking into account semantic representations of words and objects (see Johnston and Barry, 2006
47 for comprehensive review). However, language processing is a complicated process that requires
48 involvement of both lexical and semantic representations. The semantic hypothesis assumes that
49 the magnitude of AoA effect will be higher in tasks that require access to semantic level of
50 language processing. The main assumption is that semantic processing will be faster and more
51 accurate for early acquired words because they are assumed to enter the representational system
52 first and later acquired words were built up upon them, i.e. stronger semantic networks for
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3 earlier items. Hence, early acquired words influence the way late acquired words are
4 represented. Brysbaert and colleagues (2000) have employed a variety of semantic task to test
5 this hypothesis. For example, Brysbaert et al (2000) showed that the time needed to create a
6 semantic associate was faster for early acquired words than for the words acquired later in life.
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10 Despite the fact that semantic hypothesis has been a highly influential explanation of the
11 AoA effect it nevertheless received criticisms. Izura and Ellis (2004) disputed against the
12 semantic hypothesis presenting evidence from L2. According to their research, AoA effects in
13 L2 depend on the age at which the word has been acquired in second language (L2) but not on
14 the age at which corresponding L1 words was learnt. Therefore it means that semantic
15 representation is shared between two languages and this fact challenges the semantic hypothesis.
16 Noteworthy is that exploring how AoA affects free recall in bilinguals is one of the aims of the
17 current study and will be further discussed in relation to Experiment 2.
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21 It is important to note at this stage that accounts for AoA introduced above were based on
22 mostly on behavioural data explained within localised representations in the mental lexicon.
23 Connectionist accounts of language processing were also developed to account for AoA effects.
24 One such perspective is the cumulative frequency hypothesis (Zevin and Seidenberg, 2002)
25 which critiqued word naming experiments from a methodological perspective. The main critique
26 was that previous studies did not control cumulative frequency, that is, the total number of
27 exposures to a word. According to this model, learning is age-limited and that words learned
28 earlier are encountered to more frequently through life.
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32 According to Zevin and Seidenberg (2004) 'AoA norms are a surrogate variable for the
33 several aspects of words, including frequency trajectory as well as semantic and phonological
34 factors, that determine when they are learned' (p.32). In other words, early required words are
35 processed faster and more accurately due to the fact that they encountered more often in life than
36 late acquired words (Carroll and White, 1973; Lewis, Gerhand and Ellis, 2001). This means that
37 AoA effects could be associated with a residence time of the word in memory and a number of
38 times a participant encounters a word through their life (Johnston and Barry, 2006). Hence,
39 cumulative frequency theory suggests that AoA effect and word frequency should be matched.
40 Zevin and Seidenberg (2002) reanalysed word naming studies of Seidenberg and Waters (1989)
41 and Spieler and Balota (1997) using post hoc multiple regression and cumulative frequency
42 effect, but no AoA effect was found. However, it is important to note that the words Zevin and
43 Seidenberg (2004) tested for frequency was presented in print only. Many words acquired during
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3 the “critical period” of language acquisition are acquired in spoken form. Other factors, such as
4 the importance and necessity of the words (for example food names), emotional significance of
5 the word (words related to social interaction, e.g. positive reinforcement like “mum” and “dad”),
6 and phonological constraints (for example simple short words are learnt quicker than long and
7 more complicated words) influence the process of language acquisition (Johnston and Barry,
8 2006). The relationship between AoA and frequency is undeniable but it has been demonstrated
9 that AoA and frequency can yield orthogonal effects in studies that use carefully selected
10 materials (e.g. Cortese and Khanna, 2007; Ghyselinck, Custers and Brysbaert, 2004; Menenti
11 and Burani, 2007).

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13 Morrison, Hirsh, Chappell and Ellis (2002) employed word and object naming tasks with
14 younger (age 18 to 30) and older adults (60-90 years old) in order to test the claims of the
15 cumulative frequency hypothesis. A predicted interaction, however, between AoA and
16 participants’ age was not found. A variety of studies (e.g. Gilhooly, 1984; Morrison et al., 2002;
17 Lewis, Chadwick and Ellis, 2002) also failed to support the hypothesis. AoA was found to be a
18 more significant predictor of naming latencies of early and late acquired words than “residence
19 time”. It was shown that AoA highly influence reaction times and cannot be explained by
20 cumulative frequency account solely (Ellis and Lambon Ralph, 2000; Lewis, Chadwick and
21 Ellis, 2002).

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23 In brief, AoA has been empirically documented in a large number of studies (e.g. Belke,
24 Brysbaert, Meyer and Ghyselinck, 2005; Cortese and Khanna, 2007) and compared to frequency
25 effects (e.g. Gerhand and Barry, 1998a; Morrison and Ellis, 1995). Although the correlation
26 between word frequency and AoA is high nevertheless AoA effect cannot be explained by one
27 variable (cumulative frequency) only.

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29 The arbitrary mapping hypothesis was proposed as an alternative account to AoA effects
30 at about the same time as the semantic hypothesis (Ellis and Lambon Ralph, 2000). The authors
31 explored the AoA effect using simulations from their connectionist model and assumed that
32 AoA can affect multiple stages during word recognition. Early acquired items configures the
33 network into the most advantageous to them, but late acquired items struggle to reach the same
34 level of differentiation because the network ‘becomes increasingly stable and rigid, showing a
35 resultant decrease in its capacity to assimilate new patterns’ (p. 1108). Ellis and Lambon Ralph
36 claimed that if the mapping between input and output items is inconsistent (in case of reading
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3 irregular words) or arbitrary (when learning new object names) AoA effect will be larger for late
4 acquired items.
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7 Further simulations by Monaghan and Ellis (2002b) found evidence for the arbitrary
8 mapping hypothesis where AoA effect was found for inconsistent (irregular such as COLONEL,
9 YACHT) items only. The prediction was made the AoA effect is mostly larger when the input
10 and output items are arbitrary (inconsistent). The arbitrary mapping hypothesis postulates that
11 the AoA activates the representational level between the input and output. It means that the
12 strength of the AoA depends on how large the arbitrary mapping is. This principle is correct for
13 tasks including naming pictures and their names, i.e. orthography to phonography
14 representations are arbitrary.
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21 The arbitrary mapping hypothesis provides a strong explanation for the AoA effects
22 typically found in late acquired, low frequency irregular English words which are more likely to
23 have arbitrary mapping between orthography to phonology. However, it does not predict an AoA
24 effect where mappings between orthography and phonology are non-arbitrary, i.e. direct. The
25 claims of this hypothesis were put to the test in a word naming task in Turkish which has a
26 highly transparent orthography in which the mappings between orthography and phonology are
27 very predictable. Although previous reports of significant AoA effects emerged from other
28 relatively transparent orthographies such as Dutch (Brysbaert et al, 2000) Turkish presents a
29 much more transparent orthography in order to put to the claims of the arbitrary mapping versus
30 semantic hypothesis to the test. Raman (2006) reported a significant main effect for AoA in a
31 naming task in Turkish which was taken as evidence that AoA effects were not specific to
32 arbitrary mappings but a universal effect and a property of the semantic system.
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42 As reported above, AoA effects have been investigated in a variety of lexical and
43 semantic processing tasks. This effect has been reported in a number of tasks that require lexical
44 retrieval, for example word naming tasks. Moreover, the AoA effect is found in tasks that do not
45 require lexical retrieval, such as object recognition tasks, discussed below. Overall, AoA effects
46 are found in a variety of domains including written naming, word pronunciation tasks, face
47 recognition, recognition memory and free recall tasks (see Johnston and Barry, 2006 for
48 reviews). A few studies employing lexical decision tasks have shown that early acquired words
49 are recognised quicker and more efficient than words acquired later when they have to be
50 distinguished from nonwords (Morrison and Ellis, 1995; Nagy, Anderson, Schommer, Scott, and
51 Stallman, 1989). In English, the AoA effect has been found in lexical decision tasks showing
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3 that it primarily contributes to the retrieval of lexical phonology (Gerhand and Barry, 1999b). In
4 addition, AoA has been also found in experiments focused on object recognition and/or object
5 naming. Ellis and colleagues (2006) found that early acquired objects are recognised and named
6 faster than objects acquired later in life (Urooj, 2014). AoA effects on object naming has been
7 shown in different monolingual object naming experiments including those in English (Barry,
8 Hirsh, Johnston and Williams, 2001; Ellis and Morrison, 1998; Snodgrass and Yuditsky, 1996);
9 Spanish (Cuetos, Ellis and Alvarez, 1999) and French (Bonin, Chalard, Meot and Fayol, 2002).
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16 Picture naming is reported to be affected by a number of factors one of which is AoA
17 (e.g. Barry, Morrison and Ellis, 1997; Cuetos, Alvarez and Ellis, 1999; Snodgrass and
18 Vanderwart, 1980). Since the publication of the Snodgrass and Vanderwart (1980) picture norms
19 reporting AoA ratings a large body of research has used them in object naming and recognition
20 tasks in many languages of the world in Chinese (Weekes, Shu, Hao, Liu, and Tan, 2007);
21 English (e.g. Barry et al., 1997); French (Alario and Ferrand, 1999; Bonin, Peereman, Malardier,
22 Méot, and Chalard, 2003); Greek (Dimitropoulou, Duñabeitia, Blitsas, and Carreiras, 2009);
23 Icelandic (Pind, Jónsdóttir, Tryggvadóttir, and Jónsson, 2000); Italian (Nisi, Longoni, and
24 Snodgrass, 2000); Japanese (Nishimoto, Miyawaki, Ueda, Une, and Takahashi, 2005); Persian
25 (Bakhtiar, Nilipour, and Weekes, 2013); Russian (Tsaparina, Bonin and Méot, 2011); Spanish
26 (Sanfeliù and Fernandez, 1996; Cuetos, Ellis and Alvarez, 1999); and Turkish (Raman, 2011;
27 Raman et al, 2014).
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37 Several experiments were conducted in order to explain the AoA effect that presents in
38 word and picture naming tasks (Gerhand and Barry, 1998, 1999a; Monaghan and Ellis, 2002a,
39 2002b; Morrison and Ellis, 1995, 2000). However, most of the studies that explore AoA in
40 naming tasks used either picture or words stimuli but not both. Several studies that used both
41 pictures and their names, i.e. words, for naming report different results and suggest that different
42 mechanisms are responsible for their processing in Italian (Bates, Burani, Barca and D'amico,
43 2001) and in Turkish (Raman, 2011). In summary, words are processed the lexico-semantic
44 system while pictures are assumed to be processed by the semantic system.
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51 AoA has been investigated in a number of languages other than English which showed
52 that the AoA effect is a universal phenomenon found in a range of orthographies and is assumed
53 to be an 'inherent property of the functional architecture of lexical processing' (Raman, 2006).
54 AoA has been observed in alphabetical languages with different levels of orthographic
55 transparency. This is contrary to the predictions of the arbitrary mapping hypothesis which did
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3 not predict a reliable AoA effect in transparent writing systems (Lambon Ralph and Ellis, 2000).
4 In transparent Dutch, AoA effects were reported and the results of the study showed that AoA is
5 an important variable in the processing of visually presented words (Ghyselinck, Custers and
6 Brysbaert, 2004). In Italian, AoA was tested in word naming tasks; however it did not show any
7 effect on the speed of words' pronunciation (Barca, Burani, and Arduino, 2002). One of the
8 criticisms of the study was that the stress assignment was not controlled for in the experiment
9 and that AoA effect was reported for word naming under regular stress assignment (Wilson,
10 Burani and Ellis, 2012).
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17 One important note is that the review of AoA literature thus far has been limited to
18 mostly monolingual experiments with the exception of Izura and Ellis (2004). This is also true in
19 case of experiments that examined the role of AoA on free recall. To summarise, in English
20 Morris (1981) reported that late acquired words were better recalled than early acquired words
21 while Coltheart and Winograd (1986) and Gilhooly and Gilhooly (1979) found no effects of
22 AoA on recall. Dewhurst, Hitch and Barry (1998) found reliable AoA and frequency effects in
23 mixed lists only while late acquired, low frequency words were better recalled compared to early
24 acquired, high frequency words.
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31 Izura and Ellis (2002) employed picture naming and lexical decision tasks to study AoA effects
32 in both L1 (Spanish) and L2 (English). Spanish (L1) - English (L2) bilinguals were asked to rate
33 the age at which they thought they first learnt Spanish words. The result of the experiment
34 replicated AoA rating collected from monolingual Spanish speakers. The bilinguals were also
35 asked to rate at what age they learnt English words (L2). The results showed that AoA has an
36 effect on picture naming and lexical decision times in Spanish (L1) as well as on bilinguals'
37 picture naming and lexical decision times in English (L2). A multiple regression analysis
38 demonstrated that the AoA L2 effect was independent from the AoA L1 effect and native
39 language did not contribute to the ratings of L2 AoA. To confirm this result Izura and Ellis
40 (2002) compared lexical decision times separately for early acquired words learned in Spanish
41 and for their English equivalents acquired later in life (e.g. zapatillas (L1) – slippers (L2)). The
42 analysis showed that when participants responded to the words in Spanish (L1) they responded
43 quicker to early acquired Spanish words than to the words acquired later in English (L2). The
44 opposite tendency was registered when participants were asked to respond to the words in
45 English: even if overall their time reaction was slower, but they responded faster to the English
46 (L2) early acquired words than to the late acquired words in Spanish (L1). The AoA effects were
47 confirmed to be language specific showing that order of L2 acquisition is a crucial factor. In
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3 contrast to monolingual speakers bilinguals can start L2 acquisition after the “critical period”.
4 Izura and Ellis (2002) argue that significant neurological changes happen after this period which
5 can hinder L2 acquisition but a number of bilingual speakers start to acquire L2 much later than
6 the L1, that is, after the “critical period”. Studies of bilingual language processing must therefore
7 control for the age of L2 acquisition and/or proficiency where possible.
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12 Returning to the current study, one important note is that Russian children start to learn
13 English approximately between 8 to 10 years of age and continue to learn English as L2 until
14 graduation from high school at the age of 17. However, with higher demands on bilingualism
15 and fluency in English a portion of high school graduates continue to study English.
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18 19 *AoA and Memory* 20

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22 As has been discussed above, the AoA effect is a widely observed phenomenon in lexical
23 and semantic tasks. However, the role of AoA in memory tasks is not that obvious. One such
24 task, free recall task is used for exploring the organisation of episodic memory. Under the free
25 recall task, participants are typically presented with a list of items (words, pictures) to be learnt
26 and after a distractor task, asked to recall as many items as possible from the list.
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31 The free recall task has been instrumental in investigating the influence of AoA
32 especially whether it is involved in the organisation of episodic memory. One of the pioneering
33 studies in this respect was conducted by Morris (1981) who used a list of early and late words
34 mixed together. Morris (1981) reported that late acquired words were better recalled than early
35 acquired words. This finding was counterintuitive as early acquired items are expected to have
36 stronger representations in memory. The study was replicated by Coltheart and Winograd (1986)
37 in a pure list condition who reported null AoA effect. Dewhurst, Hitch and Barry (1998)
38 combined the experimental methods used by Morris (1981) and Coltheart and Winograd (1986)
39 in an experiment employing both a mixed list and pure list design. Dewhurst et al (1998)
40 reported a significant main effect for AoA in in the mixed list only. Participants managed to
41 recall more late acquired than early acquired words; and more words of low than high frequency
42 words. The results were taken to indicate that AoA effect was a modifiable effect prone to
43 context effects (i.e. list effects) and that late acquired words appeared to influence the encoding
44 hence the retrieval of episodic memory differently (perhaps with stronger, more permanent
45 semantic representations) than early acquired words. In the pure list condition, Dewhurst et al
46 (1998) reported only a significant frequency effect which was reversed, that is, participants were
47 better at recalling high frequency words compared to low frequency words. AoA effect was
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3 nonsignificant in the pure list condition and no interaction between the two variables. Dewhurst
4 et al concluded that ‘Findings were attributed to the more distinctive encoding of low-frequency
5 and late-acquired words’ (p284).
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9 It is important to note that evidence of the AoA effects and frequency influence on the
10 free recall has been limited to English only (Morris, 1981; Coltheart and Winograd, 1986;
11 Dewhurst et al, 1998). However, more recently, Raman et al (under review) have examined the
12 role of AoA on free recall of pictures and their names (words) in Turkish and have reported
13 contradictory findings to word recall in English. Raman et al are the first to include pictures in a
14 free recall task in order to examine AoA effects. It must be noted that the words were the picture
15 names obtained from AoA norms.
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21 Previous research on Turkish (Raman, 2006; 2011; Raman et al 2014) found a significant
22 and reliable effect for AoA in naming. This finding was contrary to the predictions of the
23 arbitrary mapping hypothesis (Lambon Ralph and Ellis, 2002) which proposed that AoA effects
24 in English came about because of ‘arbitrary’ mappings between orthography and phonology.
25 Raman (2006) tested this hypothesis in a naming task using early and late acquired words in
26 Turkish which possesses a highly predictable orthography in which orthography to phonology
27 mappings are not arbitrary. A significant AoA effect was taken to indicate that AoA was a
28 ‘global’ effect and ‘an inherent property of the functional architecture of lexical processing, thus
29 a universal factor similar to word frequency effect’ (Raman, 2006, p1049). In addition, this
30 effect was replicated in picture and word naming with adult dyslexic university students (Raman,
31 2011) further confirming the earlier conclusion. In a further study, the role of AoA was
32 investigated in a partial replication of Dewhurst et al.’s (1998) study with the addition of pictures
33 chosen from AoA norms in Turkish. The items were either early or late acquired pictures or their
34 names (words). Frequency of the items was also controlled. The study showed that high
35 frequency early words were better recalled than low frequency early words. These results
36 provided an understanding of AoA influence on the very transparent Turkish orthography. In the
37 context of the current study the AoA effects found in opaque English language (for example
38 Dewhurst et al., 1998) and in very transparent Turkish language (Raman, Raman, Ikier,
39 Kilecioglu, Uzun and Zeyveli, 2015; under review) are of great interest. This is because any
40 model that account for AoA effects should be able to do so universally across all types of writing
41 systems.
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3 In a partial replication of Raman et al (under review), pictures will also be used together
4 with their names (words) to explore if AoA affects free recall of words and pictures to the same
5 extent. It is well documented in the literature that information is more likely to be recalled when
6 it is presented in pictures compared to in words (Paivio, 1971; Rajaram, 1996). This view is
7 based on the functionalist account of human memory (Nairne, 2010) which considers the fact
8 that the processing pictures precede the processing of language (e.g., words) in the evolution of
9 human memory (Paivio, 2007).
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15 **Experiment 1: The role of AoA on monolingual Russian speakers in a free recall task**

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18 The aim of the experiment was to investigate the AoA effect on words and picture free
19 recall in Russian monolinguals. This is because there are no previous reports on AoA in Russian
20 bar two recent normative studies (Akinina et al, 2015; Tsaparina et al, 2011). It is therefore of
21 importance to establish that AoA effect in free recall exists in monolingual Russian speakers
22 before turning our attention to bilingual Russian (L1) –English (L2) speakers.
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27 One further aim of Experiment 1 was to ask participants to rate the age when they
28 thought they learnt the items after they completed the experimental task. The data were
29 subsequently used to validate the norms reported in the literature and to ensure their reliability.
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33 **Method**

34 Design

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36
37 A factorial design using a 2 (AoA: Early, Late) x 2 (Stimulus type: picture, picture
38 name/word) x 2 (List type: pure, mixed) where AoA was a within subject variable and Stimulus
39 type and List type were the between subjects conditions. The raw scores on correctly recalled
40 items was the dependent measure.
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45 Participants

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48 A total of 42 monolingual Russian speakers who were university students were recruited
49 from St. Petersburg State Paediatric Medical Academy in St. Petersburg, Russia. Participants
50 were allocated to experimental conditions as follows: 11 in pure word list and 10 in mixed word
51 list; 11 in pure picture list and 10 in mixed picture list.
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55 Materials

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3 The experimental stimuli were selected from the Russian normative data developed by
4 Tsaparina et al (2011) based on the colour picture norms (Rossion and Pourtois, 2004) of the
5 original Snodgrass and Vanderwart black and white line drawings (1980). The Russian norms
6 were standardised for age of acquisition and subjective word frequency along with name
7 agreement, image agreement, conceptual familiarity and imageability (Tsaparina et al, 2011).
8 Pictures and their names (words) were selected to be used in the picture and word recall
9 respectively. In addition an attempt was made to match early and late items also on frequency.
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15 Early and Late AoA items were carefully selected based on the following analyses: In
16 total 50 pictures (and picture names), half of which were early acquired and the other half late
17 acquired items were used. The early acquired picture mean score was 1.5 (SD=0.16); the late
18 acquired mean score was 2.6 (SD=0.64). This means that early items were acquired by
19 approximately 5.5 years of age, and late items were acquired approximately at the age of 9. A
20 comparison of early acquired with late acquired words showed a significant difference,
21 $t(24)=11.23$ $p<0.0001$, therefore upholding their status. (Russian stimuli used in Experiments 1
22 and 2 can be seen in the Appendix together with corresponding English translations and AoA
23 ratings from various norms)
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31 Procedure

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34 The study commenced after ethical approval was granted by the Psychology Ethics
35 Committee at Middlesex University and permission was given by the St. Petersburg State
36 Paediatric Medical University. Participants were tested one by one in a single session after
37 giving informed consent in a quiet room located at the Department of Clinical Psychology, at St.
38 Petersburg State Paediatric Medical University.
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43 Participants were presented with a list of pictures or picture names (words) under pure or
44 mixed conditions. The stimuli were presented using a PowerPoint presentation with each picture
45 or picture name (word) shown for 2000ms followed by a 1000ms interval before the next
46 stimulus was presented. In the first or learning phase of the experiment, participants were
47 randomly allocated to either a mixed list or a pure list condition. Under the mixed condition
48 early and late acquired items were randomly mixed. In the pure list condition two blocks were
49 created, one for early and the other for late acquired items. The presentation of the two blocks
50 was subsequently counterbalanced in order to avoid order effects. Once participants saw all the
51 items, they were given a simple mental numerical exercise to count backwards from 999 in 3s
52 for three minutes. This was to avoid a recency effect, that is, the memorisation of the last items
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3 on the list. Finally, in the recall stage of the experiment participants were provided with a blank
4 sheet of paper and asked to recall as many items as possible.
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7 After the completion of the experimental task, participants were given a rating sheet with
8 all the experimental stimuli and were asked to estimate the age at which they had acquired each
9 of the items. The AoA ratings were based on Tsaparina et al (2011) norms.
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12 Results

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15 The data analyses on the number of correctly recalled items were conducted using
16 descriptive and inferential statistics by way of a 2 (AoA: Early, Late) x 2 (Stimulus type: Picture,
17 picture name/word) x 2 (List type: pure, mixed) mixed ANOVA.
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21 Insert Table 1 here
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24 The results show a robust main effect for AoA effect in free recall irrespective of list type
25 for words [$F(1,19) = 9.44$ $p < 0.006$] and for pictures [$F(1,19) = 46.9$ $p < 0.0001$]. None of the
26 interactions reached statistical significance. It is interesting to see that the findings are contrary
27 to what has been reported in the literature for monolingual English speakers (Dewhurst et al,
28 1998) but in line with findings reported for Turkish (Raman et al, 2015; under review). To the
29 best knowledge of the researcher, this is the first report of AoA effect in Russian in a free recall
30 task for words and pictures. The implications of the findings will be discussed fully under
31 general discussion in view of current theoretical perspectives of AoA.
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38 **Experiment 2: The role of AoA effect in bilingual Russian (L1)- English (L2) speakers in a** 39 **free recall task**

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42 The aim of Experiment 2 was to replicate Experiment 1 by employing bilingual Russian
43 (L1) – English (L2) speakers in order to address the issue of whether AoA is involved in the
44 organisation of memory in L1 and L2. The method was almost identical to Experiment 1 with
45 the main difference being the addition of picture name (word) stimuli in English (L2).
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49 Design

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52 Experiment 2 employed a factorial design with a 2 (AoA: Early, Late) x 2 (Language:
53 Russian or English) x 2 (Stimulus type: picture, picture name/word) x 2 (List type: pure, mixed)
54 conditions. The AoA was within subjects and Stimulus type, List type and Language were
55 between subjects conditions. The participants were presented with either a list of picture names
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3 (words) in Russian (L1) or in English (L2) separately. The number of correctly recalled items
4 was used as the dependent variable.
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7 Participants

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9 The participants were bilingual Russian (L1) – English (L2) university students (N=40)
10 recruited from St. Petersburg State Paediatric Medical Academy in St. Petersburg, Russia
11 participated in the experiment. None of the participants studied English before the age of 8 years
12 and all of the participants were proficient L2 speakers who continued to learn English at least
13 until the age of 17 or later. The language proficiency was measured using the Schonell Reading
14 Test (1971).
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20 The allocation of 21 participants to conditions in Russian (L1) is as follows: 5 in pure
21 word list and 6 in mixed word list; 5 in pure picture list and 5 in mixed picture list. The
22 allocation of 19 participants to conditions in English (L2) is as follows: 5 in pure word list and 4
23 in mixed word list; 6 in pure picture list and 4 in mixed picture list.
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28 Materials

29 The pictures and picture names (words) used in Russian were the same as in Experiment
30 1. The items' corresponding English translations were matched to the AoA English norms using
31 Snodgrass and Vanderwart (1980) and the colour version picture norms (Rossion and Pourtois,
32 2004). Rating data collected for English (L2) at the end of the experiment were used in
33 correlational analyses reported below to ensure that items were reliably corresponded with early
34 and late AoA.
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41 Procedure

42 The procedure was the same as in Experiment 1. Stimuli were again pictures and picture
43 names (words) presented either in a pure or mixed block design for free recall. Half of the
44 participants were presented with the experimental task in Russian (L1) and other half in English
45 (L2).
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51 As in Experiment 1, after the experimental task was completed each participant was
52 asked to rate the age at which they acquired a particular picture either in Russian (L1) or in
53 English (L2). Allocation to AoA rating was based on which experimental condition the
54 participants were allocated. Therefore participants who completed the free recall task in Russian
55 (L1) rated AoA in Russian and those who completed the free recall task in English (L2) rated
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3 AoA in English. The collection of AoA ratings in L1 and L2 were used to further evaluate the
4 reliability and the validity of the Russian normative data on AoA (Tsaparina et al, 2011).
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7 Results

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9 The data were analysed using descriptive statistics and a 2 (AoA: Early, Late) x 2
10 (Stimulus language: Russian – English) x 2 (Stimulus type: Picture, picture name/word) x 2 (List
11 type: pure, mixed) mixed ANOVA.
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15 As can be seen in Table 2, recall of early words and pictures were superior to late words
16 and late pictures irrespective of list type. The findings are contrary to those reported in English
17 (Dewhurst et al, 1998) for monolinguals and line with the findings reported in Turkish (Raman
18 et al, 2015; under review). The ANOVA results showed a robust main effect for AoA effect in
19 free recall irrespective of list type for words [$F(1,19) = 9.44$ $p < 0.006$] and for pictures [$F(1,19)$
20 $= 46.9$ $p < 0.0001$]. None of the interactions reached statistical significance. To the best
21 knowledge of the researcher, this is the first report of AoA effect in Russian in a free recall task
22 for words and pictures.
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30 Insert Table 2 here
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32 The descriptive statistics in Experiment 2 reported in Tables 2 and 3 were split into recall scores
33 in Russian (L1) and English (L2) for a simpler presentation. As can be seen in both tables,
34 bilingual Russian (L2) – English (L2) participants showed a similar pattern of results to
35 monolingual Russian participants in Experiment 1. That is, early acquired words and pictures
36 were better recalled than late acquired items overall.
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41 Insert Table 3 here
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43 Interim Discussion

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45 The aim of Experiments 1 and 2 was to investigate if AoA influenced free recall in
46 monolingual and in Russian (L1) – English (L2) bilingual speakers under mixed and pure
47 conditions using pictures and picture names (words).
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52 Data from Experiment 2 were formally analysed using a 2x2x2x2 mixed ANOVA and
53 for the word data, the results showed a reliable main effect for language [$F(1,8) = 49.58$
54 $p < 0.0001$] but not for AoA [$F < 1$] and a significant interaction between-language and AoA
55 [$F(1,8) = 14.40$ $p < 0.005$]. Post hoc tests showed that while early AoA words were significantly
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3 better recalled in Russian (L1) than in English (L2) this was not the case for late AoA words. For
4 pictures there was also a significant main effect for language [$F(1,8)=86.30$ $p<0.0001$] but this
5 time also for AoA [$F(1,8)=28.60$ $p<0.001$]; none of the interactions reached statistical
6
7
8 significance.

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10 It is important to note however that although list type did not yield significant
11 differences, under English (L2) conditions participants overall performed better in recalling
12 words and pictures under the mixed list compared to the pure list condition especially for late
13 items (mean recall of late words in pure list is 2.8 versus 5.2 in mixed list, and late pictures in
14 pure list is 3.2 versus 4.5 in mixed list). Noteworthy is that when participants were required to
15 recall items in Russian (L1) contrary results were found overall with only early items being
16 better recalled under the mixed compared to the pure list condition (mean early word recall 9.8
17 vs 10.5 respectively).

18
19 One of the additional goals of Experiments 1 and 2 were to explore whether the picture
20 AoA ratings from the current study were in line with those reported in the literature (see
21 Appendix for AoA ratings from this study and Russian ratings from others). The rationale for
22 only using pictures for AoA ratings was based on the universal aspect of picture processing
23 which is assumed to be language independent (Raman et al, 2014). This also ensured that rating
24 in Russian (L1) and English (L2) had comparable results between monolingual and bilingual
25 participants. This is an important aspect of AoA experiments as AoA norms are often criticised
26 for being based on subjective ratings (see Morrison and Ellis, 1995 for an overview).

27
28 For monolingual participants in Experiment 1, the rating data for 50 items were entered
29 into a correlational analyses using Pearson's which found a significant relationship between the
30 current ratings and Tsaparina et al (2011) AoA norms [$r(50)=0.63$ $p<0.0001$]. Moreover, a
31 significant correlation was also found between the current ratings and those reported recently in
32 a large normative study for 25 languages (Lumiewska et al, 2016) for 29 items, $r(29)=0.74$
33 $p<0.0001$. For bilingual participants in Experiment 2, significant correlations were found in
34 English (L2) AoA picture ratings between the current study and the English norms reported by
35 Tsaparina et al (2011) [$r(50)=0.51$ $p<0.0001$]; the original Snodgrass and Vanderwart (1980)
36 [$r(47)=0.55$ $p<0.0001$] as well as Cortese and Khanna (2008) [$r(41)=0.51$ $p<0.005$]. For
37 bilingual participants significant correlations were also found in English (L2) AoA picture
38 ratings between the current study and the English norms reported by Tsaparina et al (2011); the
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3 original Snodgrass and Vanderwart (1980) as well as Cortese and Khanna (2008). Therefore, the
4 reliability of the items used in Experiments 1 and 2 were confidently established.
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9 10 **Discussion**

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12 The main query in this study was to investigate whether and the extent to which AoA
13 shapes monolingual and bilingual memory. It has been argued in the literature that as a
14 psycholinguistic variable AoA resides within the semantic lexicon. The monolingual data in
15 Experiment 1 showed a significant AoA effect and support the predictions of the semantic
16 hypothesis (Brysbaert et al, 2000) for words and the picture superiority effect in free recall
17 (Paivio, 1971; 2007). The results from Experiment 2 with bilingual Russian (L1) – English (L2)
18 speakers in word recall, showed a main effect for language but not for AoA; while post-hoc tests
19 following a significant interaction between language and AoA found that while early AoA words
20 were significantly better recalled in Russian (L1) than in English (L2) this was not the case for
21 late AoA words. For pictures, main effects were found for both language and AoA. To the best
22 knowledge of the authors, these findings are reported for the first time in the literature shedding
23 light onto understanding how lexico-semantic processes and memory are accessed in
24 monolingual Russian and bilingual Russian (L1) – English (L2) speakers.
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35 One other interesting outcome was the null effect for list type. Despite this descriptive
36 statistics showed that in English (L2) participants overall performed better in recalling words
37 and pictures under the mixed list compared to the pure list condition especially for late items.
38 Noteworthy is that when participants were required to recall items in Russian (L1) contrary
39 results were found overall with only early items being better recalled under the mixed compared
40 to the pure list condition.
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46 Overall, these findings are in line with the experimental hypotheses which predicted that
47 because L2 words enter into the bilinguals' lexicon later than L1, one cannot expect a
48 comparable or same magnitude of AoA effect under these circumstances. Evidence from
49 pictures show a robust AoA effect since picture processing is assumed to be language
50 independent. These results are in line with the predictions of the semantic hypothesis (Brysbaert
51 et al, 2000) and are taken to indicate the role of AoA in the ongoing construction of bilingual
52 memory. It appears that even though there may not be L1 specific effects on free recall in L2, L2
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speakers differ from monolinguals in terms of the semantic organization of their language processing system.

For Peer Review

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Condition	List type					
	Pure			Mixed		
	Mean	SD	N	Mean	SD	N
Early words	8.6	1.63	11	8.6	1.58	10
Late words	7.5	1.63		6.6	1.90	
Early pictures	10.8	2.4	11	10.6	1.43	10
Late pictures	7	1.9		8.4	2.72	

Table 1: Mean (in number of recalled stimuli), their corresponding standard deviations (SD) and number of participants for free-recall task in monolingual Russian speakers under pure and mixed list types in Experiment 1.

Condition	List type					
	Pure			Mixed		
	Mean	SD	N	Mean	SD	N
Early words in Russian	9.8	0.84	5	10.5	1.52	6
Late words in Russian	6.2	2.2		5.5	2.66	
Early pictures	11.6	1.52	5	10.2	0.84	5
Late pictures	8.4	2.41		6.6	1.52	

Table 2: Mean (in number of recalled stimuli) and their corresponding standard deviations (SD) and number of participants for free-recall task in Russian (L1) in Experiment 2

Condition	List type					
	Pure			Mixed		
	Mean	SD	N	Mean	SD	N
Early words in English	7.6	1.14	5	8	2.2	4
Late words in English	2.8	1.48		5.2	1.26	
Early pictures	5.5	1.38	6	5	1.41	4
Late pictures	3.2	0.98		4.5	1.49	

Table 3: Mean (in number of recalled stimuli), their corresponding standard deviations (SD) and number of participants for free-recall task in English (L2) in Experiment 2

Appendix

AoA ratings from the current study together with Tsaparina et al (2011); Snodgrass and Vanderwart (1980) and Lumiewska et al (2016) AoA norms

English	Russian	Ratings from the current study	Tsaparina, Bonin, Meot 2011	Luniewska et al 2016	Snodgrass Vanderwart 1980
1. accordion	аккордеон	1.84	2.94		4.83
2. airplane	самолет	1.07	1.61	3.55	2.59
3. anchor	якорь	2.19	2.26		4.88
4. apple	яблоко	1.07	1.26	2.52	1.91
5. arrow	стрелка	1.19	2.13		3.97
6. axe	топор	2.21	2.23	5.57	4.38
7. ball	мяч	1.12	1.26	2.03	1.34
8. balloon	шарик	1.16	1.45	2.93	2.03
9. banana	банан	1.05	1.74	2.73	1.90
10. bee	пчела	1.07	1.48		2.28
11. book	книга	1.30	1.39		1.83
12. broom	метла	2.23	1.97	4.29	2.97
13. cat	кот	1.02	1.26	2.02	1.36
14. chair	стул	1.19	1.39	2.65	1.86
15. church	церковь	2.28	2.58		2.62
16. cigar	сигара	1.63	3.81		4.09
17. cigarette	сигарета	2.05	3.32		3.62
18. clothespin	прищепка	1.65	2.06		3.31
19. corn	кукуруза	1.51	1.97		2.94
20. cow	корова	1.28	1.35	2.46	1.90
21. cup	чашка	1.09	1.42		1.66
22. dog	собака	1.12	1.39	1.99	1.55
23. doll	кукла	1.09	1.35	2.36	1.55
24. door	дверь	1.23	1.26	2.62	1.97
25. ear	ухо	1.07	1.26	2.34	1.82
26. envelope	конверт	1.37	2.35	5.08	3.93
27. eye	глаз	1.12	1.23	2.35	2.00
28. flower	цветок	1.14	1.35	2.75	2.15
29. fork	вилка	1.12	1.52	2.79	2.24
30. glove	перчатка	2.35	2.06		3.12
31. guitar	гитара	2.63	2.48	4.71	5.41
32. hammer	молоток	1.98	2.03	4.81	3.55
33. kite	коршун	2.74	2.45		3.72
34. knife	нож	1.19	1.65	3.32	2.70
35. lamp	лампа	2.65	2.52	3.90	2.72
36. leopard	леопард	2.77	2.03		4.18
37. lion	лев	1.98	1.52	2.92	2.82
38. peach	персик	2.58	1.68		2.79
39. peacock	павлина	1.51	2.06		5.18
40. penguin	пингвин	1.72	2.10	3.97	5.12
41. pipe	труба	2.12	2.68		4.07
42. pitcher	кувшин	1.60	2.19		4.07
43. rabbit	кролик	1.14	1.48	2.63	2.61
44. screw	винт	1.88	2.74		4.45
45. shoe	обуви	1.14	1.32	2.39	1.94
46. spoon	ложка	1.02	1.32	2.36	1.97
47. stove	плита	1.44	2.00	2.72	2.72

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48. table	стол	1.00	1.35		2.45
49. tree	дерево	1.23	1.32	2.47	2.03
50. window	окно	1.07	1.35		2.28

For Peer Review