Word naming slows picture naming but does not affect cumulative semantic interference.

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Abstract

Two experiments are reported which investigate the effect of processing words prior to naming target pictures. In Experiment 1, participants named (read aloud) sequences of five printed prime words and five target pictures from the same semantic category, and also sequences of five prime words from a different unrelated semantic category to the five related target pictures. Picture and words were interleaved, with two unrelated filler stimuli in between prime and target stimuli (i.e. a lag of 3 between primes and targets). Results showed that across the five target picture naming trials (i.e. across ordinal position of picture), picture naming times increased linearly, replicating the cumulative semantic interference (CSI) effect (e.g., Howard, Nickels, Coltheart & Cole-Virtue, 2006). Related prime words slowed picture naming, replicating the effects found in paired word prime and picture target studies (e.g., Tree & Hirsh, 2003). However, the naming of the five related prime words did not modify the picture naming CSI effect, with this null result converging with findings from a different word and picture design (e.g., Navarrete, Mahon & Caramazza, 2010). In Experiment 2, participants categorised the prime word stimuli as manmade versus natural, so that words were more fully processed at a conceptual level. The interaction between word prime relatedness and ordinal position of the named target picture was significant. These results are consistent with adjustments at the conceptual level (Belke, 2013; Roelofs, 2018) which last over several trials at least. By contrast, we conclude that the distinct word-to-picture naming interference effect from Experiment 1 must originate outside of the conceptual level and outside of the mappings between semantics and lexical representations. We discuss the results with reference to recent theoretical accounts of the CSI picture naming effect and word naming models.

Keywords: Word reading, picture naming, cumulative semantic interference, bias effect

The picture naming retrieval times for adults become slightly more delayed for each picture that is named from a given semantic category (Brown, 1981). This semantic interference effect has been replicated by other researchers while controlling for potentially confounding factors (Howard, Nickels, Coltheart & Cole-Virtue, 2006). It is frequently referred to as cumulative semantic interference (CSI), and there has been a steady interest in exploring and understanding the effect (e.g.,Alario & Moscoso del Prado Martin, 2010; Belke, 2013; Hughes & Schnur, 2017; Kleinman, Runnqvist, & Ferriera, 2015; Mulatti, Calia, Fara de Caro & Della Sa, 2014; Hoedemaker, Ernst, Meyer & Belke, 2017; 2014; Navarrete, Mahon & Caramazza, 2010;Oppenheim, 2018; Rose & Abdel Rahman, 2016; Scalritti, Peressotti & Navarrete, 2016; Schnur, 2014). This is perhaps because it is considered more broadly to reflect the dynamic workings of a language production system in preparation for everyday conversation (e.g., Oppenheim, Dell & Schwartz, 2010; Roelofs, 2018).

Two influential accounts of the CSI effect include persistent changes in the strength of connections between semantic and lexical representations (Howard, Nickels, Coltheart & Cole-Virtue, 2006; Oppenheim et al., 2010). A third account, which is also able to explain cumulative facilitatory categorisation effects, argues for persistent changes within the semantic/conceptual level (Belke, 2013). The models incorporate persistent adjustments because the changes in picture processing times for each successive category member survives intervening unrelated trials. However, Roelofs (2018) suggests a more temporary bias effect, given more recent evidence that the CSI effect only survives more than 8 unrelated intervening trials when there is also a short lag included between related trials (Schnur, 2014; see also Wheeldon & Monsell, 1994). Roelofs' (2018) account extends the earlier influential spreading activation WEAVER ++ model (e.g., Levelt, Roelofs & Meyer, 1999; Roelofs, 1992). These accounts maintained that the retrieval of a picture name involves lexical conceptual activation, with activation spreading then to lemmas (syntactically specified abstract lexical representations), morphemes and phoneme representations (and subsequent phonological and phonetic encoding stages). The WEAVER ++ model has successfully simulated Stroop-type picture-word interference effects, for example. The new addition (Roelofs, 2018) involved adding a temporary bias effect at the lexical conceptual stage, after selection of a lexical concept (e.g., after naming a dog). This would result in a bias towards this particular concept when another related concept is activated, slowing subsequent lexical selection. The bias would increase for successive items named from the same category. Roelofs' simulations using this modified model mimicked a number of other behavioural semantic effects, including CSI effects in picture naming and semantic blocking effects. By contrast, the CSI models of Howard, Nickels, Coltheart and Cole-virtue (2006) and Oppenheim, Dell and Schwartz (2010) have not as yet accounted for all of these three effects (picture-word interference, semantic blocking, CSI).

Whether long-lasting or more temporary, according to these models, such changes to the cognitive system would only be expected when mappings between representations are relatively indirect and via semantics, as outlined above. By contrast, the naming of printed words can operate via direct mappings between orthographic and phonological (lexical) word representations (e.g., Coltheart, Rastle, Perry, Landon & Ziegler, 2001; Grainger, Lete, Bertand, Dufau & Ziegler, 2012; Harm& Seidenberg, 2004; Roelofs, 2018), and does not necessarily require semantic activation. Oppenheim et al. (2010) note that there should be little or no cumulative transfer from word naming to picture naming. The experiments reported here build on recent work concerning the present or absence of semantic interference effects as a result of processing words prior to naming pictures.

Navarrete, Mahon and Caramazza (2010) and Belke (2013) reported results consistent with the prediction made by Oppenheim et al. (2010); there was no evidence of cumulative transfer from naming words to naming pictures (in Italian, and German, with determiner). Roelofs' subsequent (2018) temporary bias account of CSI and other semantic interference effects accommodated the absence of cumulative effect from words to pictures; no bias is introduced at a conceptual level when naming printed words. Yet, naming times for pictures can be slowed when adults have previously named (read aloud) a printed word prime from the same category as a target picture (Tree & Hirsh, 2003; Tree, Hirsh & Monsell, 2005; Vitkovitch, Cooper-Pye & Leadbetter, 2006). The effect survives two or more unrelated filler trials, and can also be found when a set of semantically related words is named in a single block before a set of target pictures, so that strategic processing of the prime word is minimised (Vitkovitch, Cooper-Pye & Ali, 2010; see also Vitkovitch & Humphreys, 1991, for error priming from naming word primes in a block prior to naming related pictures). Therefore it is a relatively long-lasting effect, affecting picture naming times when pictures are presented at least half a minute later, and after unrelated intervening trials. Current accounts of word and picture naming remain silent concerning the effect.

When primes were paired with pictures, and separated by two unrelated filler trials ("Lag 3" paradigm, Vitkovitch et al., 2006), we referred to the interference from earlier naming words as "word-to-picture" interference, and will do so here too. In subsequent work using either that paradigm (Vitkovitch & Cooper, 2012) or the blocked prime word paradigm (Vitkovitch et al., 2010), we investigated the possible contribution of controlled processing of the prime word, and the data allowed us to argue against strategic prime word elaboration or anticipation of picture targets. Rather, the semantic interference effect appeared intrinsic to the word naming trial, and likely to be automatic. Tree, Hirsh and Monsell (2005) considered semantic attractor basins as a potential locus for the interference. Vitkovitch, Cooper-Pye and Leadbetter (2006) had concluded that their data overall were consistent with a direct (orthography to phonology) route to word naming, despite the mixed word and picture paradigm. However, we did not rule out the possibility that word-to-picture interference might result from activation of an indirect semantic pathway to word naming, shared with picture naming (Harm & Seidenberg, 2004; Taylor, Duff, Woollams, Monaghan & Richells, 2015). This route to word naming might operate on a slower time course than the direct orthography to phonology route. Or there could be activation of semantics after production of the prime name (Vitkovitch & Cooper, 2012; Wheeldon & Monsell, 1992). The more recent results of Navarrete et al. (2010) are not consistent with the suggestions that we earlier made, given the absence of transfer from word naming to picture naming in their CSI study. Here, we use a different experimental design to evaluate this further.

The first experiment extended the previous paired prime and target Lag 3 design used by ourselves and others (e.g., Wheeldon & Monsell, 1994; Tree & Hirsh, 2003) and combined it with aspects of the CSI picture naming paradigm. We presented five word primes interleaved with five picture targets, each separated by two unrelated filler trials (see also Runnqvist, Strijkers, Alario & Costa, 2012). Hence there were five target pictures from the same semantic category (five levels of what is usually referred to as the "ordinal position" factor). The experiment also included related and unrelated prime word conditions for direct comparisons, and therefore avoided potentially confounding switch costs which may have influenced the target picture naming times in the previous mixed word and picture CSI studies (Navarrete et al., 2010; see also Belke, 2013). Therefore, there were either 10 stimuli from the same semantic category (5 related words, 5 target pictures), or 10 stimuli from two different categories (5 unrelated word primes, 5 target pictures).

Some CSI picture naming studies have used 8 (e.g., Crowther & Martin, 2014) and even 10 experimental stimuli, similarly analysing five key picture target stimuli across ordinal position, manipulating the remaining intervening experimental stimuli (Kuheln & Rahman, 2015; Runnqvist et al., 2012; see also Alario & Moscoso del Prado Martin, 2010, for discussions of effects with up to 10 ordinal positions and possible non-linearity). These studies report linear effects, including some differences in the strength of the linear effect across picture naming conditions. None used printed word stimuli alternating with picture naming.

We expected to replicate the CSI effect for the five picture naming targets (Howard et al., 2006), predicting a significant linear component to the ordinal position factor. We also expected to replicate the interfering effect of word primes on picture targets (i.e. a main effect of prime type, as reported by Tree & Hirsh, 2003; Vitkovitch et al., 2006). Of interest was whether or not this design might expose any cumulative effect of naming related word primes on picture naming, evidenced by an interaction between the linear component of the ordinal position factor and word prime relatedness. In the context of current accounts of the picture naming CSI effect, an interaction result would imply some relatively long-lasting adjustment within the shared word and picture cognitive system[1] (e.g., either from a contribution of the semantic route to word naming or as a result of automatic activation of semantics after naming the word). This could then parsimoniously explain the word-to-picture interference effect from previous studies of single pairs of word primes and picture targets. If, on the other hand, only a main effect of word prime relatedness is found, then consideration should be given to a distinct mechanism to account for this particular effect.

Experiment 1

Method

Participants

Thirty-six participants studying at the University of East London took part in the experiment. There were 18 women, and age ranged between 18 and 30, with a mean of 23 years. All but two participants had learnt English from birth, but these two participants reported learning English before the age of five.

Stimuli

Ten semantic categories (e.g., clothes, furniture, animals), were selected, each with ten exemplars (see Appendix for full list of stimuli). Five of the exemplars within each category were presented as printed words (related primes), the other five exemplars as target pictures, to give five ordinal positions for picture naming, within each specific category. All pictures were selected from the

[1] The studies presented here were not specifically designed to distinguish between temporary bias effects (Roelofs, 2018) or incremental or error-based learning accounts of CSI effects (e.g., Belke, 2017; Howard et al., 2006; Oppenheim et al., 2010). Relatively short lags are used in both experiments.

International Picture Naming Project (Szekely et al., 2004). For each participant, half of the picture targets stimuli from the ten categories were presented with their related prime words, and the remaining five categories were presented with printed words which were the names of exemplars from five other categories which were unrelated to the experimental stimuli (exemplars from jewellery, toys, stationery, parts of the body, buildings). Across the participant group, the experimental target stimuli (Lists A and B) were rotated across related and unrelated conditions.

In addition to the 100 experimental prime and target stimuli, there were 100 unrelated filler stimuli. Half of these were presented as printed words, and half as pictures. The sequence of stimuli for a semantic category was as follows ; prime word (related or unrelated), unrelated filler word, unrelated filler picture, target picture, and this was repeated four times, so that all five prime words and target pictures were presented from a given category (i.e. 20 stimuli in a full sequence).

Procedure

The experiment was conducted according to British Psychological Society ethical guidelines, and gained approval from a member of the ethics panel within the School of Psychology. All participants gave written consent.

Participants were asked to read aloud the printed names of objects, and retrieve the names for any pictures aloud, as quickly but as accurately as possible. Prime words and target pictures were randomised to ordinal position within a given category sequence, and the ten categories (related and unrelated) were randomised for each participant separately. Each stimulus was preceded by a fixation point for 1000 ms, followed by the word or picture stimulus, which was displayed on the screen until the participant made a naming response. They used a handheld microphone, and the presentation and recording of naming times was by E-prime software (Psychological Software Tools, Pittsburgh, PA). The experimenter recorded response accuracy, and then there was a 3000 ms interval until the next stimulus. The experimental block of 200 stimuli was preceded by one practice block of 20 stimuli, with the same sequences of stimuli (word, word, picture, picture).

Results

Median naming times to target pictures at each ordinal position were calculated for each participant, excluding any naming and hesitation/machine errors (mean accuracy was above 80% in all conditions).Figure 1 gives the target picture naming times for each ordinal position, averaged across the participant group.

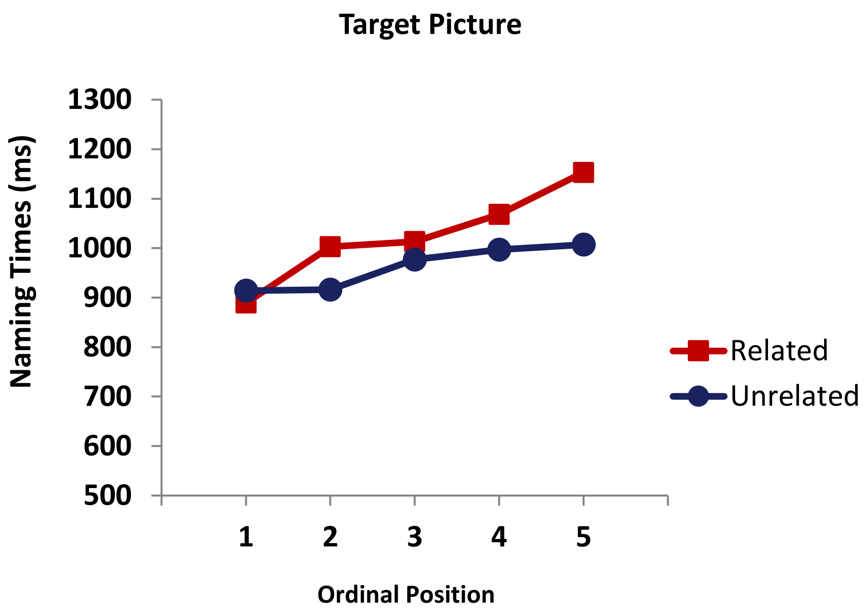

Figure 1. Mean of median picture naming times for each ordinal position, for related and unrelated prime conditions.

The ANOVA included rotation of materials (2 levels) in addition to the two within-participants factors (ordinal position, relatedness).   Relatedness effects did interact with material rotation, because one set of stimuli took longer to name than the other set, but there were no interactions of this material counterbalancing factor with effects involving ordinal position[2]. The results for the two experimental factors are as follows. The main effect of relatedness was significant, F(1,34) = 4.41, p = .043, MSerror = 81719.7, partial eta squared = .115. The main effect of ordinal position was significant, F(2.62,91.70) = 4.74, p = .006, MSerror = 108370.48, partial eta squared = .119. There was no interaction between these two factors, F(2.65, 92.87) = 1.07, p = .372, MSerror = 101297.52, partial eta squared = .03. The polynomial contrast analysis indicated that the predicted linear effect of ordinal position was significant F(1,34) = 10.74, p = .002), MSerror = 124539.39, partial eta squared = .235, and this did not interact with the relatedness factor. No other effects were significant (p values >.10).

There were no significant effects from the ANOVA of target picture accuracy scores, although the Relatedness x Ordinal position interaction approached significance, F(1,34) = 2.23, p = .069, MSerror = .378, partial eta squared = .062. Accuracy for ordinal position 3 for the relatedness condition only appeared slightly lower than the other positions. There was no evidence of any speed/error trade-off.

We also analysed the prime words naming times in a similar ANOVA, but there were no significant experimental effects (all p values > .10),and no linear or quadratic effects in the polynomial contrast analysis (mean naming times across ordinal positions 1 to 5, respectively, were 637.5, 629.4, 643.7, 622.4, 625.2).

Finally, an analysis of the filler (unrelated) picture naming times yielded no experimental effects in the initial ANOVA (p values > .05). However, naming times showed a tendency to become faster over ordinal position; the contrast analysis indicated a significant linear trend (p = .01).However, this linear component for ordinal position interacted with Relatedness and rotation of materials (p = .03). Separate (post hoc) analysis of rotations indicated a linear trend (and no other effects) evident in

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[2]The rotation of materials across the participant groups was included as a counterbalancing factor in all analyses, and any interactions of materials with significant experimental effects (Relatedness main effect, Ordinal position main effect, and their interaction) will be reported.

one rotation (means for ordinal positions 1 to 5 were 1124.3, 1141.8, 999.3, 939.9, 1006.9) but not the other. The latter, when analysed separately, indicated a quadratic and higher order interaction with condition (means for Related condition were 950.8, 993.0, 1121.2, 866.3, 869.9 and for Unrelated condition, 934.4, 862.9, 854.0, 946.5, 900.2). The unexpected pattern of naming times for the unrelated filler pictures did not mirror the predicted target picture increase in naming time over ordinal position.

Discussion

The data replicated the CSI effect for target pictures from the same semantic category (Howard et al., 2006). There was no evidence for any similar effect for the unrelated filler pictures, and therefore no indication of any general slowing effects across trials. We also replicated the interfering effect of a related word prime on picture targets (e.g., Tree & Hirsh, 2003; Vitkovitch et al., 2006). However, ordinal position did not interact with relatedness. Hence there was no evidence that the picture naming CSI effect was modified as a result of naming five semantically related word primes.

To assess whether sequencing within the semantically related conditions influenced the prime word naming process, we also analysed the word primes. Prime word processing could be affected as a result of processing previously named semantically related words within the sequence, or as a result of naming related target pictures within the sequence. Effects of ordinal position or relatedness or the interaction of relatedness with ordinal position could be indicative of such effects. However, there were no significant effects in the overall analysis or the contrast analysis, and this held also if only prime word ordinal positions 2 to 5 were analysed. Therefore there was no evidence from the word processing data for an overlap in processing for word naming and picture naming e.g., no evidence that word naming was reliant on an indirect semantic route to naming, operating in the same way as picture naming (cf. Vitkovitch et al., 2006), nor was there any clear evidence that word naming was generally affected by naming the related pictures or related words within the same sequence.

The data are consistent with word naming accomplished by a direct pathway from orthographic representations to lexical/phonological representations (see also Vitkovitch et al., 2006). The data imply that word naming does not result in any adjustments at a conceptual or subsequent stage of word naming, which might be shared with picture naming (Navarrete et al., 2010). The absence of an interaction between ordinal position of picture and relatedness of word prime suggests that the explanation for word-to-picture interference is distinct from the explanation of the CSI picture naming effect. We consider this further in the General Discussion.

Experiment 2

The second experiment investigated whether or not promoting semantic processing of word prime stimuli would modulate the picture naming CSI effect. Participants were asked to decide whether the prime words depicted manmade or natural objects. Interestingly, Belke (2013) made use of a manmade versus natural picture categorisation task within her series of studies, and found evidence for facilitatory effects over ordinal position (successfully simulated by Roelofs, 2018). This result supported her account of relatively long lasting changes within conceptual representations (conceptual features, lexical concepts), which she suggests can also account for the picture CSI effect.

In order to perform the categorisation of pictures, Belke (2013) proposed that responses might be determined on the basis of activation of relevant semantic features, subsequent to viewing the picture. For example, for a particular concept such as a necklace, this might include activation of a "manmade" feature, or activation of a more superordinate concept "jewellery". This in turn might activate any such "manmade" feature. Activation could accumulate in these diagnostic features with participants assessing the activation, allowing them to make a decision. Or else the categorisation responses could be formed on the basis of relevant activation of two task-specific nodes. If learning/adjustments were made within the conceptual system as a result of the response (e.g., between shared features and the concept), then subsequent pictures which required the same categorisation response and which shared these features might benefit. By contrast, naming several related pictures requires different responses, and activation of specific identifying features would be required for each picture.

Belke (2013) predicted that if adjustments were made at a conceptual level during both picture categorisation and picture naming, then there should be "cross talk" between the two tasks e.g., categorising pictures should affect subsequent picture naming, making it more difficult due to the need to individuate features after conceptual adjustments within shared features. Although she found some evidence that naming pictures affected picture categorisation, she did not find clear evidence that the categorisation of pictures affected subsequent picture naming. However, she considered that there could potentially be a trade-off between facilitation and interference effects in this case (see also Scalritti et al., 2016). She concluded that simulations of the transfer between categorisation and naming tasks would be helpful to establish conceptual crosstalk (overlap) between the two tasks.

Although the current experimental choice of the categorisation task was primarily motivated by a more general goal of promoting semantic processing of the word prime to observe if the picture naming CSI effect was now affected, it is relevant to consider any cross-talk effects within the framework offered by Belke (2013)[3]. Moreover, the difference in designs across laboratories may prove useful. If Belke or Roelofs (2018) are correct, and changes at the conceptual level do contribute to the CSI effect (see their discussions of the origin versus locus of effects), then it follows

[3] We thank an anonymous reviewer for highlighting this approach and for suggestions concerning feature activation

that semantically classifying word primes as manmade or natural prior to picture targets should have an effect on the related target picture naming CSI effect.

In the case of word categorisation in the present experiment, activation of relevant semantics, such as specific diagnostic features as suggested by Belke (2013), might be direct from orthography, or via the orthography to phonology to semantic route (e.g., Grainger et al., 2012; Harm & Seidenberg, 2004). Roelofs' WEAVER ++ model would also allow access to semantics from the lemma stage of lexical representation (Roelofs, 2018). The WEAVER ++ model allows for printed word stimuli to activate lemma representations, hence in this particular model, lemma representations would be common to both word and picture naming. In contrast to the reading aloud of printed words (Experiment 1), this word categorisation task is less well-rehearsed, and likely requires more controlled semantic processing (cf. Lambon Ralph and colleagues, e.g., Rogers, Patterson, Jefferies & Ralph, 2015). Likewise, the categorisation of pictures as manmade versus natural (Belke, 2013) may well be achieved more readily than word categorisation, given object surface features may be useful for the decision (Bruce, Carson, Burton & Ellis, 2000). Therefore the current use of a word categorisation task may well promote cross-talk effects.

The design in Experiment 2 was similar to Experiment 1 (word prime, filler word, filler picture, target picture), and therefore included an unrelated control condition, but now participants classified word stimuli as manmade or natural. They continued to name all picture stimuli. If, for example, a temporary conceptual bias (Roelofs, 2018) is introduced for each conceptually processed word, then arguably the picture naming CSI linear effect should be more pronounced under related as compared to unrelated conditions (see also Hoedemaker et al., 2017, for a discussion of CSI effects and depth of comprehension). Or the CSI picture naming effect may increase as a result of accumulating and long lasting conceptual changes in shared class features after categorising words, which must then be overridden (Belke, 2013). It will also be of interest to assess whether or not, given Belke's (2013) results with picture categorisation, the categorisation response times for prime words across ordinal position may decrease. Moreover, will any such facilitatory effect be reduced for the related condition, as compared to the unrelated condition, indicative of cross-talk between the two tasks?

On the other hand, a failure to find any interaction between picture ordinal position and prime word relatedness would be more consistent with the two other picture naming models (Howard et al., 2006; Oppenheim et al., 2010), which emphasise the relevance of unidirectional semantic to phonological mappings during picture naming.

Method

Participants

A total of 40 participants took part in the experiment, from the University of East London. Age ranged between 18 and 38, and the mean age was 24 years, and there were 22 women. There were 33 bilingual participants. The data from four participants who had not learnt English before the age of five were not analysed. The data from one other participant was removed due to procedural error.

Stimuli

Target pictures were the same as for Experiment 1. The same sequencing framework was used for each of the 5 ordinal positions within a category (prime word, word filler, picture filler, picture target). The related categories from Experiment 1 had included 2 natural categories in each rotation, and 3 manmade categories, so could usefully remain as such for the new prime categorisation task. Necessarily, because they belonged to the same specific category (e.g., birds) related word primes and target pictures within a sequence of 20 stimuli (5 primes and 5 targets and their fillers) were all either manmade, or all natural. Therefore, in constructing the unrelated condition for Experiment 2, even though participants did not overtly categorise target pictures, we endeavoured to keep this aspect constant across conditions. So unrelated primes were also from the same broad classification as their five targets, and we discuss this point later (e.g., the five unrelated word primes from the category jewellery were all manmade, as were the target pictures (e.g., vehicles) within that sequence of 20). Further, when rotating the materials, we ensured that the unrelated prime categories maintained the same response as for the related prime word. These considerations necessitated changing two of the unrelated categories that had been used in Experiment 1 (see Appendix). We also ensured that filler words included both natural and manmade response unpredictably within the sequences of 4 stimuli. Overall, there were more manmade response than natural (see also Belke, 2013).

Procedure

The experiment was conducted according to British Psychological Society ethical guidelines, and gained approval from a member of the ethics panel within the School of Psychology. All participants gave written consent.

Participants were asked to categorise the word stimuli out loud, as either manmade, or natural, and to name the pictures. They received a short practice block, and then proceeded to the experimental block of 200 stimuli (5 related and 5 unrelated sequences of 20 stimuli). As for Experiment 1, primes and targets within a category were randomly allocated to ordinal position, and related and unrelated categories were presented in a random order too. All other aspects of the procedure were as for Experiment 1.

Results

Median response times were calculated for each ordinal position for each target picture, for each participant, excluding incorrect naming responses and hesitations and machine errors (mean accuracy was above 60% for all conditions, though two participants were excluded during naming time analysis due to an absence of correct responses in one condition). Figure 2 shows the averaged naming times for each condition for each ordinal position.

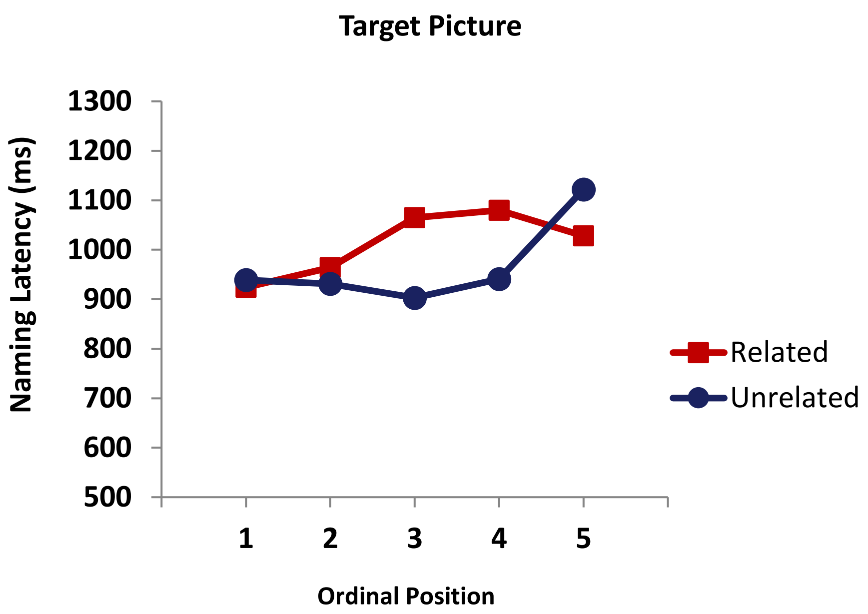

Figure 2. Mean of median picture naming times for each ordinal position, for related and unrelated prime conditions in Experiment 2.

For target picture naming times, the main effect of prime relatedness was not significant,F(1,31) = 1.36, p = .252, MSerror = 85709.37, partial eta squared = .042. This interacted with the material rotation. One set of materials had longer naming times than the other set. The main effect of ordinal position was significant, F(2.59, 80.35) = 3.33, p = .03, MSerror = 100945.64, partial eta squared = .097, as was the ordinal position x relatedness interaction, F(4,124) = 3.32, p = .013, MSerror = 58169.38, partial eta squared = .097. There were no further interactions of these latter two effects with materials.

The contrast analysis of target picture naming times revealed a significant linear component for ordinal position, $F(1,31) = 6.87$, $p = .013$, $MSerror = 118712.48$, partial eta squared.181. For the relatedness x ordinal position interaction the quadratic component was significant, $F(2,31) = 9.69$, $p = .004$, partial eta squared = .238. Simple effects analysis of ordinal position for each relatedness condition indicated a significant linear ($p < .05$) and significant quadratic component ($p < .05$) for ordinal position for the related condition. For the unrelated condition, the linear effect approached significance ($p = .075$) while the quadratic component was not significant ($p = .104$). For accuracy to target pictures, there were no significant effects in the ANOVA (p values > .05).

Analysis of the categorised word primes indicated no effects in the main ANOVA ($p >.10$), but in the contrast analysis, the linear component was significant ($p < .05$), and there was a tendency for the facilitation over ordinal position to be more marked for the unrelated (means over ordinal position, 1246.4, 1169.3, 1160.1, 1093.1, 1109.9) as opposed to related condition (1175.6, 1181.1, 1166.3, 1177.9, 1153.7). The interaction of the linear component for ordinal position with priming conditions was not, though, significant, $p = .057$. However, post hoc simple effect contrast analysis of the linear component to the ordinal position for the related condition was not significant ($p > 10$), nor were there any other significant effects. For the unrelated condition, the analysis yielded a significant linear trend ($p = .008$). (Means averaged over prime conditions were 1050.5, 1020.3, 1014.8, 1012.7, 1026.6).

The analysis of naming times for the unrelated (named) picture fillers gave no significant effects for the experimental effects (1050.5, 1020.3, 1014,8, 1012,7, 1026.6), all p values> .10, including for the polynomial contrast analysis.

Discussion

The trend analysis of the word prime categorisation times did suggest facilitation across prime word ordinal position, which is similar to Belke's (2013) findings for picture categorisation. There was a tendency for this to be less marked for related conditions (the relevant interaction approached significance). A *post hoc* analysis confirmed that the linear component was significant for the unrelated condition, but not for the related condition. Given this, the effect is unlikely to be located solely at the output stage. Instead it is relevant to consider the data with respect to Belke's suggestions concerning cross-talk between picture naming and manmade/natural picture categorisation.

One possibility is that the individuation of conceptual features which is required for picture naming may attenuate any adjustments involving shared features relevant to the classification of the related prime words. For unrelated word primes, even though their respective picture targets were from the same broad (man-made or natural) category, picture naming re-adjustments to any earlier categorisation prime conceptual changes could be minimal, given less conceptual overlap between the different categories (e.g., jewellery word primes and vehicles target pictures). Such an account couched within Belke's (2013) discussion of shared versus individualised features for categorisation and naming (and converging responses for categorisation versus divergent responses for naming) seems a plausible explanation for the apparent cross-talk from picture naming to word categorisation. Roelofs (2018) account can also generally accommodate facilitation over ordinal position in categorisation tasks, due to temporary conceptual bias and converging responses. However, further work is clearly needed to test and specify these accounts of word categorisation response times more adequately, especially given the absence of a statistically significant interaction. Experiments which focus on different types of unrelated word primes are currently underway.

The target picture naming results showed that classifying printed word prime stimuli as manmade or natural affected the picture naming CSI effect; relatedness of word prime stimuli interacted with ordinal position. Belke (2013) did initially predict that object naming tasks would be more difficult after categorisation, though her specific working model was not fully supported. As noted earlier, it is likely that the manmade/natural categorisation task of words requires a deeper processing than that of pictures, and the nature of the design used here may have exposed effects more readily. Here, we give a brief comment on the nature of the interaction for the target picture naming trials.

The separate analysis of target picture naming times for the related condition confirmed a significant departure from linearity, with no increase in naming times after the 4^{th} ordinal position. As we noted earlier, in purely picture naming studies which have used 10 experimental stimuli, any departures from linearity have not been noted (see Introduction to Experiment 2; but see also Scaltritti et al., 2016, for one example of a quadratic trend across five ordinal positions for picture naming). Within the framework offered by Belke (2013), this suggests a limit or slow build-up to any conceptual adjustments to relevant shared features, such that four categorisation trials sufficiently facilitate picture naming. It is less easy to see how Roelofs (2018) account of temporary bias would account for both the increase in picture naming times up to ordinal position 4 and then attenuation, given that within a sequence, there was never an absence of related word primes for more than 8 trials (when the bias returns to zero). Perhaps the locus of the bias effect within the conceptual system could change as a result of increasing experience of the categorisation task. Investigations of longer sequences than the current 10 stimuli would clearly be useful.

By contrast, for the unrelated prime condition, the picture naming linear trend only approached significance when the target pictures were analysed, suggesting that semantically processing the prime words from a different category to target pictures (though the same broad natural or manmade category) may generally attenuate the picture naming CSI effect. Given the unrelated prime and target shared at least some features (both natural or both manmade items), then some facilitatory word priming at the conceptual level in the absence of lexical competition may have offset CSI interference during picture naming (Belke, 2013; see also Abdel Rahman & Melinger, 2009). On the other hand, Roelofs (2018) temporary conceptual bias account could explain a less pronounced build-up of picture naming CSI effects in the unrelated condition; the switching between categorising and naming two largely different and unrelated categories may suspend or diminish temporary bias within these sequences, for example. Further work is needed to investigate these suggestions, but like Belke (2013), we agree that there appears to be some "cross-talk" between the two tasks, and that simulation with existing models would be helpful.

To return to our initial consideration, the finding that the picture naming CSI effect is modified when words are necessarily processed semantically supports the conclusion that the semantic processing of words was minimal (and did not result in incremental learning) when they were named in Experiment 1, albeit indirectly. In the final discussion, we consider the pattern of results across the two experiments more fully.

General Discussion

The picture naming data from Experiment 1 replicate previous findings of CSI effects (e.g., Howard et al., 2006). However, there was no change in the CSI effect as a consequence of naming a series of related word primes denoting objects from the same semantic category (Experiment 1), though related prime words did interfere with naming pictures. By contrast, in Experiment 2, categorising word related primes as manmade or natural did affect the CSI picture naming effect. The contrasting results across the two experiments suggests that there are two distinct picture naming interference effects arising from the differential processing of words. We discuss word processing in relation to the picture naming CSI effect in each experiment, before returning to consider the word-to-picture interference effect. The recent theoretical accounts of CSI effects are considered to see which can most readily accommodate the current effects.

The absence of an interaction between relatedness of word naming and ordinal position of target picture naming in Experiment 1 usefully converges with similar null findings from a word and picture CSI paradigm in which direct comparisons across related and unrelated word primes conditions were not possible (Navarrete et al., 2010). There, picture naming responses could potentially have been influenced by the costs of switching between stimuli types (see also Belke, 2013), and may have obscured weak modifications to picture naming CSI effects as a result of word naming. Thus two different paradigms have now reported null effects of word naming on the CSI picture naming effect. As highlighted in the introduction, the absence of any modified CSI effect does not conflict with any of the existing CSI models. The null effect is anticipated by at least one account (Oppenheim et al., 2010), given the independent research on word naming specifies a direct orthography to phonology route to reading (e.g., Coltheart et al., 2001; Harm & Seidenberg, 2004). Hence a word naming trial does not appear to result in any strengthening (or weakening) of the mappings between semantics and phonology relevant also to the picture naming pathways (Howard et al., 2006; Oppenheim et al., 2010; Navarrete et al., 2010), or within the conceptual level per se (Belke, 2013; Tree & Hirsh, 2005). Neither was there any evidence of any cross-talk from picture naming to word naming. Considering also the recent account which suggests temporary adjustments as a result of lexical concept selection, there is no evidence for any such bias effect after word naming (Roelofs, 2018). On the other hand, the novel result from the less well-rehearsed word categorisation task used in Experiment 2 does imply some modification to the CSI accounts of Howard et al. (2006) and Oppenheim et al. (2010).

Experiment 2 exchanged the prime task, so that participants had to semantically process the prime word, deciding whether or not it depicted a manmade or natural object. As outlined in the introduction to Experiment 2, access to semantics from words can either be as a result of orthography to semantic mappings, which are unlikely to be shared with picture naming[4], or as a result of mappings to semantics from phonological forms (Harm & Seidenberg, 2004). The interaction of prime relatedness and ordinal position for the target picture naming data (i.e. the modification to the picture naming CSI effect as a result of prime word categorising) suggests word prime processing in this task resulted in a relatively long lasting change to shared components of processing. In the discussion to Experiment 2, we considered Belke's (2013) claim for relatively long lasting structural changes within the conceptual level, acknowledging her discussion of the relevance of shared conceptual features to the categorisation task versus the individuation of conceptual features required for picture naming. As she detailed, re-adjustments may be necessary as an individual moves from one task to the other task, for semantically related pictures. As we noted, there is therefore scope within this existing account for understanding how related word classification could attenuate the semantically related picture naming CSI effect in the current Experiment 2. Similarly, we also considered that Roelofs' (2018) temporary bias addition to the WEAVER model might be able to account for a failure to demonstrate a clear CSI effect for the unrelated picture naming condition, though it was unclear why there should be a departure from the linear increase across ordinal condition in the related condition.

Considering the incremental and error learning models (Howard et al., 2010; Oppenheim et al., 2010), Belke (2013) suggested that some modification would be required to these models to account for cross-talk between her picture manmade/natural classification and picture naming tasks. One possible modification to these two models which might accommodate picture naming results from Experiment 2 might be the addition of bi-directional connections between semantic and phonological representations i.e. the mappings from phonological to semantic representations that are likely to be activated during semantic word categorisation might be one and the same as the

[4] Recent work has indicated that there may be some activation of orthographic codes during language production, at least for Mandarin, though evidence of this is conflicting for other languages (Damien & Qu, 2019; see also Wheeldon & Monsell, 1992)

mappings from semantic to phonological representations. However, it is not entirely clear why this would attenuate the CSI picture naming effect after approximately 8 or 9 related stimuli.

How then should we account for the Experiment 1 replication of the interfering effect of words on pictures when words are simply named (Tree & Hirsh, 2003; Tree et al., 2005; Vitkovitch et al., 2006)? Our earlier suggestion was that word-to-picture interference might be explained by relatively slow automatic activation of the orthography to semantic to phonology pathway, subsequent to the efficient (orthography to phonology) word naming trial (Vitkovitch et al., 2006; Vitkovitch & Cooper, 2012). This does not now hold up. As we have noted above, data from two different paradigms have not shown any evidence of any long-lasting adjustment within conceptual representations or in the mappings between semantics and phonology, as a result of word naming. A mechanism for word-to-picture interference which does not overlap with the explanations discussed above for the CSI picture naming effects is required, and this needs to be relatively long lasting.

Interestingly, to account for a particular pattern of target picture naming errors (but not naming times) as a result of naming related a previously presented word primes, Vitkovitch and Humphreys (1991) did briefly consider that word prime naming might activate a broad pool of phonological to semantic mappings. Picture errors did not relate specifically to word primes, but there was some evidence that they corresponded to “other” unseen but related objects (see Vitkovitch & Cooper, 2012, for further discussion of error types). However, in order to simultaneously account for the specific perseverative errors found when target pictures were preceded by named picture primes, Vitkovitch and Humphreys proposed that these mappings would need to be differentiated from the (feedforward) semantic to phonology mappings. Relatively long-lasting adjustments to a broad set of mappings from phonology to semantics could potentially account for word-to-picture interference naming time effects, if phonological representations were reactivated during target picture naming, but not subject to a competitive lexical selection process (see below). This would not be incompatible with, for example, the conceptually-based accounts (Belke, 2013; Roelofs, 2018) considered above for the Experiment 2 CSI results. By contrast, this distinct phonological to semantic mapping account of word-to-picture interference would be a contradiction of our suggested modification above to the two remaining CSI models. [5]

In other work, we considered the Lag 3 word-to-picture interference in the context of the response exclusion account of Stroop-type picture –word interference effects (Vitkovitch & Cooper, 2012). Potentially, the target picture trial could reactivate the related word prime, and slowed naming times would result from the need to remove the word response from an articulatory buffer (cf. Mahon, Costa, Person, Vargas, & Caramazza, 2007). We reasoned that if there was retrospective processing of the related prime word (e.g., retrieval of an episodic trace) during target picture processing, then participants should show evidence of better memory for such primes. However, we found no clear evidence that this was likely to be the explanation for word-to-picture interference. Roelofs (2018) maintains that the WEAVER ++ model remains a good explanation of Stroop type picture-word interference effects. In this model, the picture-word interference effect is located at the lemma level (competitive lexical selection mechanis), and, as noted earlier, printed words can also activate lemmas directly in WEAVER ++. It is worth considering whether a lemma origin locus may explain the longer-lasting word-to-picture interference effect too.

If, after word naming, lemma activation decayed only after about 30 seconds (to accommodate the approximate timing in the present Experiment 1 and other work - see Introduction), then this could slow subsequent semantically related picture naming at a competitive lexical selection stage due to reactivation during semantically related picture naming (though see also Tree et al., 2005, for

[5] Our other suggestion (Vitkovitch & Humphreys, 1991) that naming printed words may generally raise semantic activation (and, in cascade, a broad pool of semantic to name mappings but with no adjustments to connections), does not appear to fit with the current data. If, for example, broad-based activation remained at the conceptual level, one might then expect word naming effects on picture naming times to at least minimally resemble the current Experiment 2 data.

a possible argument against lemma level interference)[6]. However, it is unlikely that word-to-picture interference is due just to the most recently named semantically related prime word, given our other work which presented all related words (two or more from each of several categories) before target pictures (Vitkovitch et al., 2010), and given some evidence for “other” errors (Vitkovitch & Humphreys, 1991). Rather, it seems likely that more than one lemma representation (from the same semantic category) might be a potential competitor during subsequent picture naming. If this is so, any competitive lexical selection mechanism (see also Howard et al., 2006), would need to remain unaffected by the actual number of lemmas activated, given the CSI effect remains unaffected (Experiment 1).

The WEAVER ++ (lemma and lexeme) model could potentially be modified to allow for the word-to-picture interference effect to emerge after competitive lemma selection; word naming could result in a change in the strength of the connections between lemma and lexeme. Wheeldon and Monsell (1992) argued for this as an explanation for repetition priming response time effects in picture naming. Their series of experiments using definitions as primes allowed them to argue against the relevance of the phonological representations per se (though also implicated orthographic and semantic influences in specific priming effects). Nevertheless, repetition priming from printed word prime naming to target object naming over long intervals was found in one of their experiments (see Bruce et al., 2000, for a discussion of methodological differences across studies with regard to printed word repetition priming). If word naming in the mixed word and picture naming study in the current Experiment 1 similarly resulted in an increase in strength of connections between lemma and lexeme representations, then semantically related phonological representations would be re-activated during target picture naming. Some mechanism would be

[6]Wheeldon and Monsell (1994) located a semantic interference effect at the lemma level, for their definition prime and target picture study. This was because the effect was not found to be as persistent as repetition priming, which they located in lemma to lexeme mappings. Their study did not investigate CSI effects, but the point about durability of the semantic interference effect in picture naming is relevant.

needed to account for slowed picture naming times (and absence of modification of CSI effect). Perhaps a differential threshold based on the most highly activated lexeme could explain the word-to-picture effect (see Oppenheim et al. (2010) for a discussion of differential threshold).

One final suggestion concerning the origin of the word-to-picture interference draws on recent research within the short term memory tradition. The locus of the effect could again remain "outside" of any competitive lexical selection process. Effectively there could be an activated lexical cohort within memory[7]. However, some accounts of verbal short term memory are linked closely to activation within linguistic representations (e.g., Savill, Ellis & Jefferies, 2017; see also Harley, 2008), and include semantic influences (Chiou & Lambon Ralph, 2018; see also the working memory episodic buffer of Baddley & Hitch, e.g., 2018). Any semantic lexical cohort within a buffer could in principle include a range of semantically related items, not just those previously named (and hence could explain "other" errors). It may not be tied to serial order (Marjerus, 2018). One function of a buffer system may be to facilitate conversation around a given topic (Savill et al., 2017; see also Roelofs, 2018), perhaps by a parallel matching process, when cued by initial broad semantic information when expressing ideas or naming objects. On the basis of the repetition priming results referred to above, we would predict facilitatory effects whenever the memory cohort includes, in addition to any other semantically related primes, the correct name of the object to be named. However, if a previously named set of printed words does not actually include the correct name, as in the case of word-to-picture experiments here, there may be a small negative effect[8] of keeping a small range of recently named and other items in the buffer. It can be noted, though, that the effect size of word-to-picture interference in the present study (12 %) is not very large!

[7] We thank A. Melinger for suggesting the term lexical cohort for picture-to-word interference, at a conference presentation.

[8] This account need not equate to the post-lexical response exclusion account of picture-word interference (e.g., Mahon et al., 2007), although a monitoring process may be a relevant mechanism (e.g., Dhooge & Hartsuiker, 2013). Moreover, picture naming responses need not be excluded from any such cohort. Rather, word prime naming may expose such a cohort, as the efficient naming pathway may allow them to readily enter the memory system.

Summing up, we have replicated the CSI picture naming effect and replicated a paired word prime and target picture interference effect. In line with other findings, we have not found any evidence that the naming of words affected the CSI picture naming effect. We have also provided novel data in Experiment 2 showing that semantic categorisation of word primes can influence (attenuate) the CSI picture naming effect, with some indication too that picture naming may modify word categorisation effects. Thus we have evidence for two distinct effects. The cross-talk between the Experiment 2 tasks (word categorisation, picture naming) supports recent claims for relatively long term changes within a conceptual stage of processing (Belke, 2013), and seems partially consistent with a more recent a conceptually located temporary bias mechanism, introduced by Roelofs, (2018). Both of these accounts have also offered explanations also for picture naming CSI effects. The two other picture naming CSI accounts (Howard et al., 2010; Oppenheim et al. 2010) would require some modification to explain the cross-talk effects found in Experiment 2. The current experiments were primarily designed to help explain the word-to-picture interference effect replicated in Experiment 1, given our previous work supported the conclusion that it is a relatively automatic effect. The data indicate that naming printed words aloud (at least in this experimental context) does not result in any relatively long term adjustments at a conceptual level or in the connections between semantics and an initial lexical stage of processing. With respect to at least two of the current models, the origin and locus of word-to-picture interference would be better explained as external to any competitive lexical selection mechanism. The effect could originate within the connections between lemma and lexeme representations, or within a separate set of mappings from phonological to semantic representations. We also offered one speculative memory-based account to explain word-to-picture interference effects. On balance, the recent work which allows for relatively long lasting changes at a conceptual stage appears to fare better at accommodating the results from both Experiments 1 and 2.

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Appendix

<u>Target pictures for Experiment 1and 2</u>

SET A

Animals – elephant, monkey, mouse, squirrel, deer

Fruit – lemon, apple, banana, pear, grapes

Clothes – scarf, pants/trousers, sweater/jumper, tie, sock

Furniture – table, chair, stool, bed, highchair

Tools – wrench/spanner, saw, screw, pliers, drill

Set B

Kitchen utensils - corkscrew, fork, bowl, spoon, plate

Vehicles – car, boat, train, helicopter, truck

Birds – owl, eagle, chicken, swan, parrot

Musical instruments – drum, saxophone, harp, guitar, trumpet

Insects - spider, ladybird, ant, scorpion, bee

Related prime words used in Experiment 1 and Exp 2

Set A

Animals – wolf, camel, goat, lion, rabbit

Fruit – strawberry, mango, plum, peach, orange

Clothes – blouse, shirt, coat, dress, belt

Furniture – dresser, cupboard, shelves, couch, desk

Tools – nail, hammer, axe, chisel, clamp

List B

Kitchen utensils – grater, tray, peeler, knife, cup

Vehicles – coach, van, aeroplane, motorcycle, bus

Birds – crow, duck, sparrow, goose, pelican

Musical instruments - piano, whistle, flute, violin, banjo

Insects – cockroach, grasshopper, moth, beetle, wasp

Unrelated primes Experiment 1

Body parts– lips, neck, elbow, eye, nose

Jewellery- brooch, tiara, crown, chain, ring

Buildings - castle, church, house, igloo, apartment

Stationery - stapler, paperclip, biro, pencil, paper,

Toys - rattle, puzzle, ball, teddy, balloon

Unrelated primes Experiment2 (two unrelated categories changed from Experiment 1 to match manmade/natural related categories)

Celestial items - cloud, lightning, moon, rain, sun

Geographical items – volcano, mountain, desert, river, lake

Buildings – castle, church, house, igloo, lighthouse

Stationery – biro, pencil, paper, paperclip, stapler

Toys – ball, balloon, puzzle, rattle, teddy