Introduction

In investigating the efficacy of acquired dysgraphia treatments, relatively little attention has been directed to the relationships amongst treated items. Is it beneficial or detrimental to treat together items that belong to the same semantic category or share segments (phonemes or letters)?

In spoken production, interference is observed when individuals produce items in the context of other semantically related vs. unrelated items—neurologically normal participants initiate naming more slowly and individuals with aphasia produce more errors (e.g. Damian et al., 2001; Schnur et al., 2006). On the other hand, facilitation is observed for the production of blocks of phonologically related vs. unrelated items—normal participants initiate naming more quickly (e.g. Damian, 2003), although there is some evidence of interference in individuals with aphasia (Hodgson et al., 2005).

In the present study, we extend this research to examine the effects of semantic and orthographic blocking on written production in neurologically intact individuals (Experiments 1A and 1B) as well as one individual with acquired dysgraphia (Experiment 2). While the investigation does not involve treatment, the findings may have implications for word retrieval treatment.

Experiment 1A: Semantic Blocking

Method

Participants. Twenty-four undergraduate students.

Stimuli. Thirty-six black and white line drawings from six semantic categories (Schnur et al., 2006) were used (Figure 1). Each semantically related block consisted of six exemplars from one category; each mixed block consisted of one exemplar from each category. Within each block, there was low orthographic overlap between items (mean position-independent orthographic overlap=0.21 for semantically related blocks, 0.20 for mixed blocks measured per Goldrick et al., 2010).

Procedure. Participants completed twelve blocks of experimental trials, writing on a digitizing tablet. On each trial, a picture appeared on the screen until participants began writing. In each block, six pictures from one list were presented four times, for a total of twenty-four trials. Each participant completed the twelve blocks in a different order.

Results

Participants responded significantly more quickly (mean difference of median response times=27.76 msec) in unrelated blocks than in semantically related blocks, $F(1,23)=45.328$, $p<0.001$. There was no difference in error rates ($p>0.05$).

Experiment 1B: Orthographic blocking

Method

Participants. Twenty-four different undergraduate students.

Stimuli. Black and white line drawings of thirty-six items were used (Figure 2). Each orthographically related block consisted of six items with high position-independent orthographic overlap (mean=0.56). Each mixed block consisted of six items —one from each related block —with low orthographic overlap (mean=0.16). Items in a block were never from the same semantic category.

Procedure. Same as Experiment 1A.

Results

Participants responded more quickly (mean difference of median response times=17.09msec) in mixed versus orthographically related blocks, $F(1,23)=4.233$, $p<0.05$). They made significantly more errors in orthographically related versus mixed blocks, $t(6910)=2.019$, $p<0.05$.

Experiment 2: Semantic and orthographic blocking in acquired dysgraphia

Method

Participant. ICA was an 85 year-old right-handed female with a large left fronto-parietal lesion resulting from a left middle cerebral artery CVA seven years prior to testing. She had good auditory comprehension of concrete nouns, but severely impaired spoken and written word production. Many of her errors in writing were letter perseverations—productions of letters from previous responses in place of those from the current target — caused by a failure-to-activate deficit (Fischer-Baum & Rapp, 2012) in which target graphemes receive abnormally low activation from higher levels (Figure 3). Perseverations occur when the normal residual activation for recently produced graphemes is stronger than the activation of current target graphemes. Consistent with this hypothesized deficit, ICA perseverated at above-chance rates in spelling-to-dictation ($p<0.001$) and written picture naming ($p<0.05$) but not in direct copy transcoding ($p>0.5$).

Stimuli. Same as Experiments 1A and 1B.

Procedure. Paper copies of the line drawings were used and written responses were made on paper. In each session, ICA completed 1-2 blocks, structured as in the previous experiments. Responses were not timed. Perseveration errors were analyzed as in Fischer-Baum et al. (2010). ICA completed all experimental blocks twice.

Results

ICA produced fewer perseveration errors in semantically related blocks (69/441 letter errors) versus mixed blocks (161/452 letter errors), $\chi^2(1)=34.1$, $p<0.0001$. In contrast, she produced more perseveration errors in orthographically related blocks (181/411 letter errors) versus mixed blocks (47/387 letter errors), $\chi^2(1)=76.1$, $p<0.0001$.

Discussion

Consistent with previous results for spoken production, we observed interference from semantic blocking for written production. We also observed interference from orthographic blocking. This latter finding contradicts previous findings of facilitation from phonological blocking in spoken production. These previous studies typically used items with the same onset phonemes, which allows for strategic preparation and, hence, facilitation. Our orthographic blocking condition used items with orthographic similarity distributed across letter positions, which may not allow the same sort of preparation.

Our findings are consistent with an incremental learning explanation (Oppenheim et al., 2010). According to this account, when a lexical item is selected (e.g., dog), the weights on connections between active semantic features and the selected lexical item are strengthened, while connections between active features and other active, semantically related, competing lexical items (e.g. cat) are weakened. As a result of this weakening, production of items from the same semantic category becomes more difficult on subsequent trials. Items in unrelated blocks are not subject to the same weakening because semantic features are not shared. Therefore, participants are able to name items more quickly in unrelated versus related blocks (Figure 4). Our findings of interference from orthographic blocking suggest similar strengthening and weakening processes occur when the lexical item's corresponding graphemes are selected during the subsequent stage of segmental encoding.

Patient ICA produced fewer perseveration errors in semantically related versus unrelated blocks. This is consistent with the incremental learning account because in related blocks, representations of competing items in the block are repeatedly weakened, making them less available as sources of perseveration errors. In unrelated blocks, this is not the case and, thus, more perseverations are expected than in related blocks.

ICA's deficit affected the grapheme level (Figure 3), and therefore the activation dynamics of segmental encoding. We found that she produced more perseveration errors in orthographically related versus unrelated blocks. According to the incremental learning account, in related blocks, because of her segmental encoding difficulties, neither target graphemes nor the graphemes of related words received much activation. Therefore, weakening of connections for related words was minimal. However, strengthening of connections for the graphemes that were actually produced continued. Consequently, in orthographically related blocks, connections to the same set of letters g were repeatedly strengthened, while competitors were not weakened. This would be expected to lead to perseveration errors when target graphemes were insufficiently activated. In unrelated blocks, perseverations were less likely since the connections to the same set of letters were not repeatedly strengthened.

These findings may have implications for the grouping of items during treatment. The finding of interference with semantic and orthographic blocking suggests that blocking may increase production difficulty when activation dynamics function normally. Importantly, however, we also found that deficits may affect the normal processing dynamics. These findings indicate that it will important to consider item similarity and the nature of the deficit when selecting items to train. Clearly, however, the implications of these findings should be studied directly in the context of treatment.

References

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Figures

Mixed blocks

Semantically related blocks

bear	cat	skunk	goat	horse	dog
chin	nose	ear	toe	thumb	arm
hat	glove	dress	sock	coat	skirt
sofa	bed	table	crib	stool	chair
doll	top	bat	ball	blocks	kite
glass	spoon	cup	knife	pitcher	fork

Figure 1. Items used in the semantic blocking manipulation. Each row lists the items in one semantically related block; each column lists the items in one mixed block.

Mixed blocks

Orthographically related blocks

cat	mat	cot	cap	map	mop
pill	peg	pig	pot	log	leg
house	horse	rose	nose	robe	hose
rain	stairs	hair	stain	chain	chair
slide	bride	bread	bridge	sled	bird
belt	well	wall	bell	bull	ball

Figure 2. Items used in the orthographic blocking manipulation. Each row lists the items in one orthographically related block; each column lists the items in one mixed block.

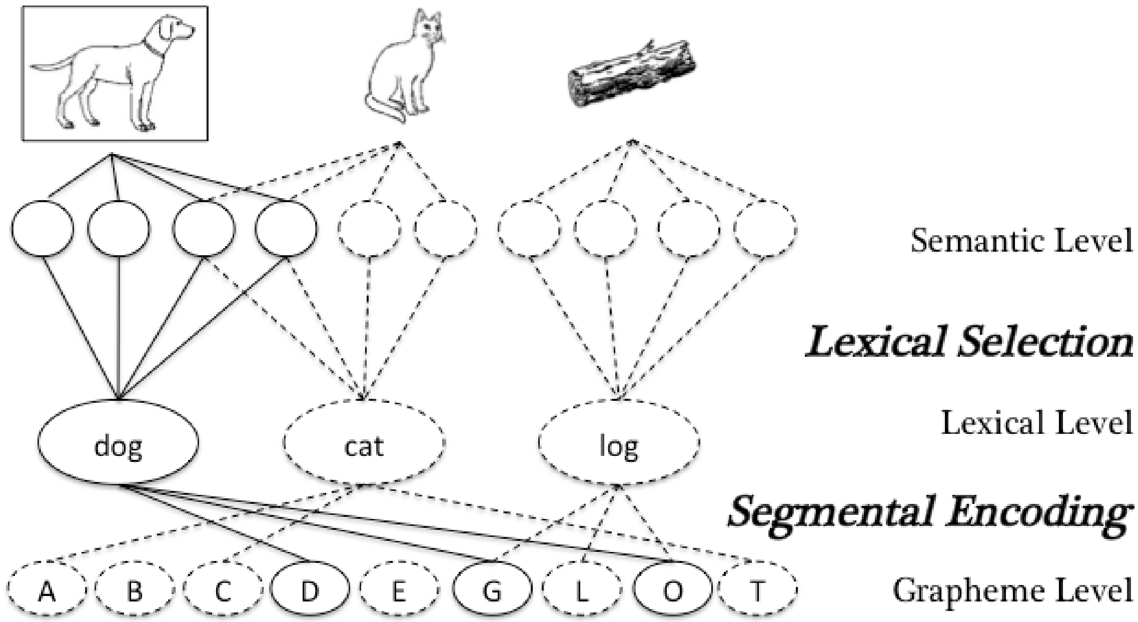

Figure 3. Architecture of written production system. There are three levels of representation: semantic, at which there is activation of features of the target's meaning; lexical, at which there is activation of lexical items that share the target's semantic features; and grapheme, at which there is activation of the constituent letters of the target lexical item. These three levels of representation are connected by two stages of processing: lexical selection, in which a lexical item is selected given the active semantic features; and segmental encoding, in which segments (letters) are selected given the active lexical item(s). Semantically related items share features at the semantic level. Orthographically related items share segments at the grapheme level. Here, the target "dog" is active (as depicted by solid lines) and there is some activation for the semantically related item "cat" and the orthographically related item "log" (as depicted by dashed lines). In a failure-to-activate deficit, graphemes receive abnormally low levels of activation from the higher semantic and lexical levels. Other active graphemes may be intruded, including those retaining residual activation from previous production.

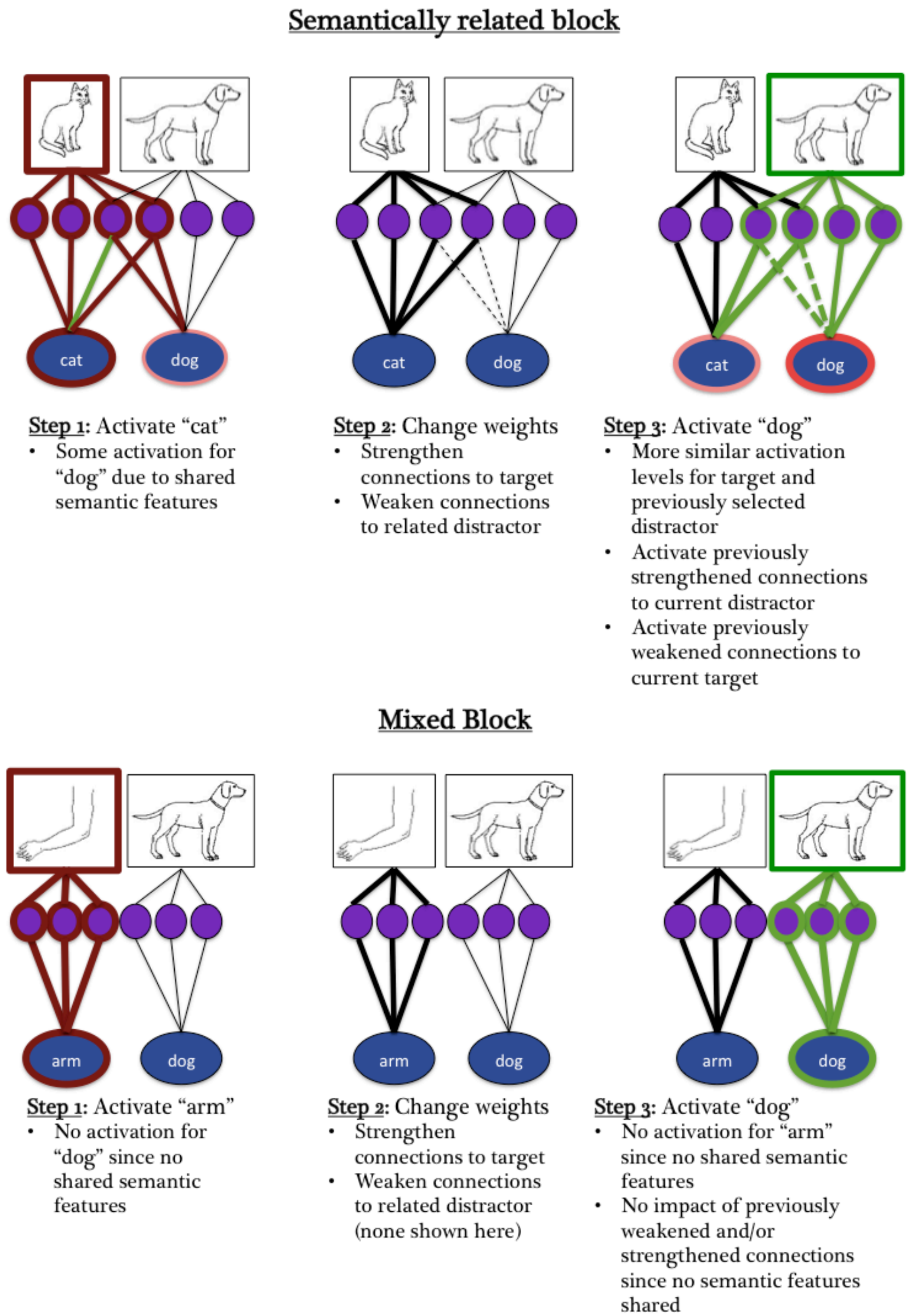

Figure 4. Depiction of lexical selection according to the incremental learning account. The top panel shows the activation dynamics at play in a semantically related block; the bottom panel shows activation dynamics at play in a mixed block