THE EFFECTS OF GENERATION ON VISUAL AND AUDITORY IMPLICIT MEMORY

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ABSTRACT

ILANA T. Z. DEW: The Effects of Generation on Visual and Auditory
Implicit Memory
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The generation manipulation produces the classic functional
dissociation between explicit and implicit memory. This dissociation
has been explained by the transfer-appropriate processing framework,
which emphasizes a match between the cognitive operations required
at encoding and at retrieval. However, the vast majority of implicit
memory studies have been conducted in the visual modality; in the
auditory modality, the effects of generation in particular have
never been investigated. Three experiments examined the effects of
generating from semantic cues on various auditory implicit tests.
Generating from antonyms produced a negative generation effect on
priming in auditory perceptual identification and word-stem
completion, while producing the traditional positive effect on
explicit recognition. Generating from definitions also produced a
negative generation effect on auditory priming. These results are
critical for characterizing auditory priming given the generation
paradigm's importance in dissociating explicit and implicit memory
in the visual domain.

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CHAPTER I

INTRODUCTION

The term "explicit memory" denotes the conscious, intentional recollection of previous experiences. "Implicit memory" refers to non-conscious, unintentional influences of memory, as some aspect of a previous experience influences or facilitates behavior in a new, seemingly unrelated condition. Researchers often look back to early cases of patients with anterograde amnesia – a deficit in the ability to form new memories – as having provided preliminary evidence of the distinction between these two forms of memory. One famous early case study details an amnesic woman whose doctor once shook her hand with a pin hidden within his palm; at a later visit, the patient refused to shake his hand. She reasoned that people sometimes hide pins in their hands, although she retained no conscious memory of this happening specifically to her (Schacter, 1987).

Employing more systematic study, Warrington & Weiskrantz (1970) provided such patients with lists of words to study. Later, when given a test that asked them to recognize or recall words from the earlier list, their performance was significantly lower than that of normal controls. However, the patients were also asked to complete word stems or word fragments – tasks in which some letters of a word

are replaced with blanks, and subjects are instructed to complete the stem or fragment with whichever words come to mind first. On these implicit tasks, the patients tended to complete the stems and fragments spontaneously with the studied words, despite any conscious awareness of doing so. This facilitation of performance, known as priming, demonstrated that unintentional, unconscious influences of memory were robust and unaffected among these patients, whose performance on the priming tasks was in fact at the level of normal controls. Similar results have been reported many times since Warrington & Weizkrantz's (1970) demonstration. (For reviews, see Shimamura, 1986; Carlesimo, 1999)

A similar population dissociation is found among patients with schizophrenia, who have difficulty with explicit remembering compared to normal controls, yet retain normal implicit memory functioning. Danion, Meulemans & Kauffmann-Muller (2001) compared schizophrenic patients and normal controls on an artificial grammar learning task, a measure of implicit learning in which subjects learn a system of new, complex rules, and are later required to indicate whether a letter string was "grammatical." They found that both the patient group and the healthy controls reached similar levels of learning, even though the patients exhibited poorer episodic memory of the study portion.

Likewise, older adults demonstrate some loss of explicit memory but typically show no deficit on priming tasks when compared to younger adults (e.g. in Light, Singh & Capps, 1986; Light & Singh, 1987). In one study by Light, LaVoie, Valencia-Laver, Albertson-

Owens & Mead (1992), the authors found that although the older
adults performed more poorly than younger adults on a recognition
test of study items, their pattern of performance was equal to that
of younger adults on both within-modality (e.g. visual-to-visual)
and cross-modality (e.g. auditory -to-visual) priming. Such
population dissociations as these imply very important differences
between these two described forms of memory.

Explicit and Implicit Functional Dissociations

Generalizing such dissociations to normal subjects in an
experimental setting is crucial, in that it allows researchers to
manipulate and control variables in a way that differential research
does not normally allow. This provides unique challenges, however,
given that normal subjects are able to use explicit retrieval
processes to aid performance on nominally implicit tests. The
typical paradigm used to examine explicit and implicit memory in the
experimental setting involves first a study portion, in which
subjects encode items in any of various ways; depending on study
goals, they may be required simply to read the items, to read them
and simultaneously think about their form or their meaning, to
generate items based on meaningful cues, or to encode them in any
other number of ways. After a brief distractor period in which they
are engaged in an unrelated cognitive task, subjects complete the
test portion of the experiment. Explicit and implicit tests are
distinguished by their instructions, in whether or not the subjects
are asked to think back to the earlier items in order to complete
the task. Common explicit tests require that the subjects recognize

or recall items from the study portion. Common implicit tasks include the word-stem and word-fragment completion tasks, as used by Warrington & Weizkrantz (1970). The perceptual identification task is a different example, in which words are presented very briefly, and participants are simply instructed to try to identify the presented word. On this task, priming is measured to the extent that earlier target words are easier to identify than are counterbalanced new words. Another common implicit task is category exemplar production, in which subjects are asked to think of items that fit a given category; here priming is demonstrated if subjects are more likely to respond with a previously studied example than with a baseline example.

Using the prototypical study-test paradigm, several experimental dissociations between explicit and implicit memory have been found in normal subjects. Priming, for example, has been shown to be unaffected by levels of processing manipulations, despite noted differences in explicit memory tests between shallow and deeper levels of encoding. In an early example, Jacoby & Dallas (1981) instructed some subjects to perform deeper-level, elaborate processing on words (e.g. asking them to make decisions about the word's meaning) and instructed other subjects to perform shallow-level processing (e.g. asking about surface-level features or the spelling of the word). Subjects were later tested with either recognition or perceptual identification. Jacoby & Dallas found that deeper processing led to better recognition than did shallow processing, but that there was no difference between the encoding

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conditions on the perceptual identification task. They found in a second experiment that, conversely, study-to-test changes in the perceptual presentation of the items affected implicit but not explicit memory. Changing from auditory to visual presentation from study to test did not affect performance on the recognition task, but significantly decreased priming on the perceptual identification task (Jacoby & Dallas, 1981).

The experimental manipulation that has perhaps most clearly dissociated explicit and implicit memory in normal human subjects has been the generation paradigm, originally shown by Jacoby (1983). In a series of experiments, participants read some words out of context (e.g. they saw a neutral stimulus followed by a target word, such as "XXX-cold"), read some words in context (e.g. within an antonym pair, such as "hot-cold"), and the remaining words were generated from a meaningful context (e.g. from the same antonym cue, "hot-???"). Subjects were later tested either on recognition of earlier target words or on the perceptual identification task. Jacoby (1983) found that on the explicit task, the generated items were better recognized than were the read items. However, level of performance on the perceptual identification task reversed this direction. Although, overall, words from the study phase were more easily identified than were new words (and thus priming was demonstrated), subjects were also in fact more likely to identify words from the read condition than from the generate condition.

This "reverse" generation effect has been explained by the Transfer-Appropriate Processing framework, which emphasizes a match

between the cognitive operations required at encoding and at retrieval. Morris, Bransford & Franks (1977) originally framed TAP in terms of goals: Challenging a levels-of-processing approach, which proposes a general superiority of deeper-level encoding, the authors suggested instead that optimal encoding processes should be defined relative to test objectives. Although prior research had suggested shallow-level encoding as less durable, when the processes required at test reengage the shallow encoding processes, even surface-level information was found to be very well retained (Morris et al., 1977).

This framework has since been broadly applied to the dissociative effects of generation on explicit and implicit retrieval tasks. The encoding-retrieval match occurring in the generation paradigm has been explained specifically as a match between "data-driven" and "conceptually-driven" processing (e.g. in Roediger & Blaxton, 1987; Roediger, Weldon & Challis, 1989). In other words, reading words at study allows subjects to process the words based on their surface-level, perceptual features. However, generating words based on an antonym cue prevents any perceptual processing (since the target word is not written), and instead requires an encoding procedure based on the word's semantic (conceptual) properties. The perceptual identification task, conversely, requires that the subject identify words based only on limited perceptual information. Performance on this task should benefit from similar perceptual processing required at encoding, and

therefore promotes the most priming for items from the read study condition (Roediger, 1990).

Since Jacoby (1983), there has been a substantial body of research exploring the generate/read paradigm on various implicit tasks. Many of these priming studies have replicated the negative generation effect, but it is important to note that not all implicit tasks produce like results. The key feature of TAP, of course, is the match between cognitive operations at study and test, be they conceptual, perceptual, or some combination thereof. Implicit tasks do not all exclusively require data-driven processing; in turn, reading may not always produce more priming than generating, but rather it depends on the nature of the retrieval task. In other words, TAP predicts such variation in priming performance to the extent that different implicit tasks require different relative amounts of perceptual and/or conceptual processing.

CHAPTER II

THE EFFECTS OF GENERATION ON IMPLICIT MEMORY

Blaxton (1989) replicated Jacoby's (1983) findings using a different generation task and various retrieval tests. In one experiment, subjects either read items without context, read items within a semantically-related pair (e.g. hawk – eagle), or generated items from a semantically-related cue. Subjects were later asked to complete one of several memory tasks. Some were given a free recall test or a semantic cued recall test, both of which should promote conceptually-driven retrieval. In line with Jacoby's findings, words from the generate condition were recalled better than the words read in context, which were recalled better than the words read with no context. Other subjects were given a word fragment completion task; on this perceptual implicit task, a reverse generation effect was found. Interestingly, when subjects completed a general knowledge test, an implicit retrieval task which should promote conceptual processing, a positive generation effect was found (Blaxton, 1989).

Smith & Branscombe (1988) produced similar results when they compared the read/generate manipulation on an explicit task and on both perceptually-based and conceptually-based implicit tasks. Subjects read some items and generated others from meaningful cues.

They were later tested on either an explicit recall task, a perceptual implicit word-fragment completion task, or a conceptual implicit category association task, in which subjects are required to think of adjectives that describe social behaviors. Like the results in Blaxton (1989), the read items produced more priming in the word-fragment completion task, whereas the generated items were both better recalled and promoted more priming on the category accessibility task than did read items.

Gardiner (1988) demonstrated more specifically that priming benefits when test items maximize overlap with the stimuli presented at study. In one experiment, subjects read study items or generated them from word fragments (e.g. Political Killer: ASSA---N). When they were later asked to complete fragments whose form did not match from study to test (e.g. A--A--IN), there was no priming difference between generated and read items. In a second experiment, when each fragment remained the same at study and test (e.g. presenting ASSA---N once again), a generation effect was found, with generated items producing more priming than read items.

Horton & Nash (1999) expanded on Gardiner's (1988) results in three experiments, which furthered the finding that performance on implicit memory tests is enhanced when the perceptual details of the study and test items overlap. In one experiment, participants either read items at study or generated items from word stems or word fragments. They were later tested on the same word stems and fragments, and were given the typical implicit task instructions to complete them with the first word that came to mind. Contrary to

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prior research in which read items generally produced more priming than generated items on word-stem completion and word-fragment completion at test, Horton & Nash here found a positive generation effect. Relative to the read words, priming on word-stem completion was highest for items generated from word stems, and priming on word-fragment completion was highest for items generated from word fragments. These results were not surprising, given the high degree of stimulus specificity between study and test. Importantly, however, the results demonstrated that the effect of the read/generate manipulation on implicit memory may be dependent on the nature of the generation task at study.

Moreover, the magnitude of the effect has likewise been shown to depend on differences among the various implicit tests. In three read/generate experiments, Schwartz (1989) compared two implicit tasks: the perceptual identification task and word stem completion. In the study portion, subjects either read items with no context, read items from a semantic associate, or generated items from semantic or orthographic cues (such as solving anagrams). Later, in the perceptual identification task, reading yielded more priming than did generating. On the word stem completion task, however, there was no reliable priming difference between the two encoding conditions. Notably, Schwartz also found no priming difference between words generated silently and words generated aloud. Although a number of studies have provided evidence for cross-modal priming (e.g. Roediger & Blaxton, 1987), this result indicated that auditory

self-input in the generate condition did not affect priming on a visual implicit task.

Similarly motivated, Weldon (1991) tested the effect of four study conditions (read, generate, auditory, and pictures) on perceptual identification and word fragment completion. She found a main effect of study condition, with read, generated, and auditory items producing significant priming on both implicit tasks. However, there were priming differences among the study conditions. On the perceptual identification task, the read words produced significantly more priming than did items from any other study condition. Weldon further examined whether this benefit of surface-level encoding for the perceptual identification tasks occurs in conjunction with, or at the exclusion of, deeper semantic coding. Interestingly, no priming was shown for pronounceable nonwords that were morphologically similar to real words (e.g. flewor – flower) despite similarity in surface-level features. Because morphologically similar real words can often act as primes (e.g. hug – huge), Weldon took this result as evidence that perceptual priming may require first accessing the study item on a lexical level, and only after this are there differences in sensitivity to perceptual stimulus overlap. This conclusion was supported as well in a prior study by Hayman & Jacoby (1989).

Although much of the research has produced corresponding results, Masson & MacLeod (1992) were unable to replicate the reverse generation effect on masked perceptual identification. In a series of experiments, subjects either read items or generated from

definitions, antonyms, homographs, or idioms. The authors' goal was to test whether the different surrounding context in read versus generate study conditions may influence the typical dissociations. As such, they reinstated study context at the time of test: Preceding the briefly presented words from the generate condition, for example, were words from the corresponding study-phase definitions. When the study context was reinstated at test, they found no difference on the perceptual identification task between read and generated items. A second point of departure comes from Mulligan (2002), in which generation tasks produced dissociated results on recall and a conceptual implicit task. In one experiment, participants were required either to read items, or to generate by transposing the first two letters of a presented word or by completing word fragments. They were later given either a category-cued recall test or the category exemplar production test. Consistent with prior research, generated items were recalled better than read items. However, there were no reliable differences between read and generated study items on the conceptual implicit task. Further, after subjects read or generated items from a meaningful sentence context, the expected generation effect was found on the category exemplar production task.

Overall, much of the results within the described body of research fit well within the predictions of transfer-appropriate processing: Priming in the read/generate paradigm is typically enhanced to the extent that the processes required at retrieval reengage the processes required at encoding. The standard

generation manipulations, in which items are generated from semantic

cues that offer little visual input, typically produce a reverse

generation effect on perceptual tests but a positive generation

effect on conceptual tests. On other hand, either a positive

generation effect or no priming difference between read and

generated items is typically found on perceptual tests after

generating from anagrams or tasks in which attention to the item's

perceptual features is required. Despite these overall patterns,

there still remain some contrary findings, in addition to many

unanswered questions regarding the processing requirements of

various encoding and retrieval tasks.

CHAPTER III

IMPLICIT MEMORY IN THE AUDITORY MODALITY

The vast majority of studies on implicit memory have been investigated within the visual modality. Relatively little is known about priming in the auditory domain. Given the high degree of stimulus specificity required to produce or enhance priming, it cannot be assumed that processing requirements in visual tasks will necessarily generalize to those required in auditory tasks. This has therefore become an important question to investigate, especially given that "perceptual" has so often been used to describe the nature of many visual implicit tasks.

The existing research within the auditory modality has established that auditory priming tasks are analogous to visual priming tasks in many ways. In auditory perceptual identification tasks, which closely resemble visual perceptual identification tasks, spoken words are presented within noise or are passed through a filter to create a degraded or muffled stimulus, and subjects are instructed to try to identify the word. The word stem completion task and word fragment completion task also have analogues in the auditory modality, in which portions of a spoken word are replaced with silence and a subject is instructed to fill in the heard stem or fragment with the first word that comes to mind.

Priming in the visual and auditory modalities is comparable in several ways. Studies with amnesic patients, for instance, have produced similar explicit/implicit dissociations in the auditory modality as in the visual modality. Schacter, Church & Treadwell (1994) presented amnesic patients and healthy controls with a series of recorded words. In the study task, they were told to focus either on surface-level features (e.g. to rate the pitch level of the speaker's voice) or on semantic features (e.g. to indicate whether the word was an animal, food, place, or occupation). Following the study portion, participants were either given an auditory recognition test or an auditory identification task, in which they tried to identify words degraded by white noise. Similar to results in the visual modality, the authors found that priming levels were similar across the patients and the healthy controls, despite the predicted difference in performance on the recognition task. Moreover, the healthy controls exhibited the predicted levels-of-processing effect on the explicit task, with words from the semantic encoding condition recognized better than words from the non-semantic encoding condition; in contrast, this study manipulation had no effect on recognition performance for the amnesic patients. On the perceptual identification task, there were no differences in priming for the semantic and non-semantic conditions in either group.

Also similar to the visual domain is the finding that age dissociates auditory implicit and explicit memory. In three experiments, Sommers (1999) required younger and older healthy

adults to listen to a list of study items and focus on either surface-level or semantic features of each item (e.g. to rate the clarity of pronunciation or to identify the number of definitions for each word). Subjects were later tested either on a recognition test or on a perceptual identification task in which spoken words were degraded by a low-pass filter. Compared to younger adults, older adults produced lower recognition performance but equivalent priming.

Pilotti & Beyer (2002) extended this finding that older and younger adults perform similarly to each other on priming tasks. The authors assigned older and younger participants to one of two study conditions: they either heard two lists of words, each spoken by a familiar voice, or they heard one list of words spoken by a familiar voice and read printed words on a second list. Across both study conditions, subjects were instructed to attend to the words' perceptual features (e.g., to rate the clarity of enunciation). In the test portion of the experiment, subjects completed the perceptual identification task in which words were degraded in noise, and in which earlier study words and new words were spoken by one of the familiar talkers. Thus, those in the hear study condition were exposed at test to some voice-matched and some voice non-matched words; those in the hear-read study condition were exposed to some voice-matched words and some words from a different modality. The results of this experiment replicated those from Light et al. (1992), in that no reliable age differences were found across modality-specific or modality non-specific priming. Providing

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additional evidence toward the general benefit of stimulus
specificity in auditory priming, the same-modality/same-voice
condition produced greater priming than did same-modality/different-
voice, which produced greater priming than did words from the
different modality condition (Pilotti & Beyer, 2002). Along the
same lines of this second result, Church & Schacter (1994)
demonstrated that study-to-test changes in voice, intonation, and
fundamental frequency significantly decreased priming on auditory
word stem completion and low pass filtered words in young adults,
although these changes had no effect on recall or recognition.

Furthering the examination of perceptual specificity in auditory
priming, Sheffert (1998) instructed subjects in the study portion to
listen to some words presented alone and some presented in noise.
Later, priming for words and voices was assessed with two perceptual
identification tests in which some test items were presented in the
same voice as at encoding, and others were not. On both tasks,
study-to-test voice changes reduced priming.

Taken together, these studies demonstrate that priming in the
auditory modality behaves similarly to visual priming. However,
other research has illuminated potential differences between the two
domains. Green, Easton & LaShell (2001) found different amounts of
cross-modal priming produced in the visual and auditory modalities.
A visual task at study produced equal priming on visual and auditory
implicit tests, but an auditory task at study only produced priming
in an auditory test. Subjects at study encoded items that have a
separate visual and auditory component (e.g. they either saw or

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heard a baby crying). At test, participants either viewed a degraded version of the same item (e.g. within enlarged pixels) or heard the item masked in noise. Priming on both visual and auditory identification tests benefited from modality specificity. However, hearing items at study actually resulted in no cross-modal priming on the visual test, whereas viewing items study resulted in significant cross-modal priming on the auditory test that was in fact only slightly less than on the visual test. Further, results of an explicit recognition test also demonstrated study-test modality effects; although overall performance was high for both study conditions, visual items at study were more likely than auditory items to be recognized when presented visually at test, and, reversing the direction in slightly greater magnitude, auditory items were more likely than visual items to be recognized when presented aurally at test.

A second line of research that points to potential differences between visual and auditory priming comes from Schacter & Church (1992). In five experiments, subjects listened to a series of items and were asked to focus either on a semantic feature of the word (e.g. category, pleasantness) or on the pitch of the word presentation. On auditory perceptual identification as well as on word stem completion, the focus on category produced equivalent priming as the focus on pitch, a result that is consistent with the typical lack of levels-of-processing effects in the visual modality. Interestingly, there were no priming differences on perceptual identification between a pitch-match and a pitch-non-match from

study to test (both when subjects were required to focus on pitch at study as well as following a focus on category). However, following both a focus on pitch and focus on pleasantness, there were highly significant differences between pitch-match and pitch-non-match on word stem completion. These results contrast with a study by Graf & Ryan (1990) on perceptual identification in the visual modality, in which different magnitudes of priming following study-to-test changes in surface features (e.g. typefont) occurred after focusing on surface information at study (e.g. rating the legibility of a word), but not after focusing on semantic features.

Pilotti, Bergman, Gallo, Sommers & Roediger (2000a) demonstrated that differences in sensitivity to study-to-test changes of perceptual features may depend on differences among various implicit tasks themselves. Differences in priming following study-to-test changes in modality and voice were compared across four implicit and two explicit tasks. In one experiment, subjects read or listened to a series of words; after each, they were asked to rate the extent to which they understood the meaning of the item. Performance was subsequently compared across perceptual identification (when masked in noise), perceptual identification (when masked by low-pass filter), word stem completion, word fragment completion, recognition, and cued recall.

Across all four implicit tasks, changes in modality from study to test reduced, but did not eliminate, priming. However, voice changes from study to test affected only the perceptual identification tasks: There was no difference in priming between

same voice and different voice in word stem completion or word fragment completion. Overall, these findings indicate that auditory priming tasks differ in their reliance on purely perceptual auditory information at encoding. Interestingly, the explicit tests also showed sensitivity to perceptual information; performance on recognition diminished from study-to-test voice changes, and performance on cued recall diminished from study-to-test modality changes (Pilotti et al., 2000a).

Research by Pilotti, Gallo & Roediger (2000b) produced different results. At study, subjects either heard words, imagined words spoken by the heard voice, or read words silently. The inclusion of the second study condition was under the assumption that imagining words spoken in a particular voice involves some of the same perceptual processing as does actually hearing the voice, despite the absence of actual auditory input. Subjects were later tested on two explicit tasks (recognition and cued recall) and on three implicit tasks (masked identification, low-pass filter and word stem completion), in which some items were presented by the same voice as in the study portion and some in a different voice. Results showed that hearing words at study produced more priming on all three implicit tasks than did imagining or reading words, and moreover, the voice match between study and test benefited priming for heard words as compared to a voice non-match. Study-to-test voice changes and changes in modality, on the contrary, had no reliable effect on the explicit tasks. Imaging words produced as much priming as did reading words, yet disrupted performance on recall and recognition.

CHAPTER IV

GENERATION AND AUDITORY IMPLICIT MEMORY

Although the described studies are informative for comparing auditory and visual priming and for providing general support for the TAP framework, many questions remain. Specifically, no study has investigated the effects of generation on auditory implicit memory. This is crucial, given that the reverse generation effect is the classic functional dissociation supporting the distinction between implicit and explicit memory. Moreover, the effects of generation on visual implicit tests have been used by the TAP account to classify tests as perceptual or conceptual (e.g. in Roediger & McDermott, 1993); although auditory priming tests appear similar to visual priming tasks in several ways, there has been no assessment of their "perceptual" status with this important criterion.

An appropriate starting point for this question, then, is to examine whether Jacoby's original read-generate manipulation can be replicated in the auditory domain. It is chiefly this question which motivates my first experiment. I recreated Jacoby's (1983) within-subjects study conditions: subjects heard some words without context; some words were heard in context; and the remaining words were generated from an antonym cue. The test portion of the experiment replaced the visual perceptual identification task with

the auditory identification task in which words are masked by white noise. (Further details are described in *Method* as Experiment 1.)

A logical subsequent experiment utilized the same study materials as Experiment 1, but replaced the identification task with an auditory word stem completion task. Generalizing the results of the first experiment to this task is important not only for making broader predictions in regards to auditory implicit memory, but is especially motivated given that in the visual domain, perceptual identification and word-stem completion have in some cases been shown to differ in sensitivity to perceptual features (e.g. in Schwartz, 1989). Comparisons between perceptual identification and word-stem completion in the auditory modality have also varied. In some (non-generation) auditory priming studies, no differences were found between the two tests (e.g. Church & Schacter, 1994). Others, however, found word stem completion to be less sensitive than perceptual identification to perceptual study-to-test changes (e.g. Pilotti et al., 2000a).

Lastly, it was important to investigate whether the results could be extended to semantic generation tasks in which targets are generated from cues other than antonyms. A task of particular interest was generating items from their definitions. Some studies using this manipulation have produced the typical reverse generation effect, and are therefore consistent with TAP (e.g. in Winnick & Daniel, 1970; Clarke & Morton, 1983; Schwartz, 1989). Masson & MacLeod (1992), however, found that generating from definitions produced as much priming as did reading, a result that cannot easily

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be explained by TAP. Their findings are particularly germane given the results of a recent preliminary study of mine in which no priming differences were found between items heard and generated from definitions on auditory perceptual identification. Experiment 3 extended this by investigating the effect of generating from definitions on auditory word-stem completion.

Method

   Participants. Thirty-six undergraduates participated in partial fulfillment of a course requirement in an introductory psychology course at the University of North Carolina at Chapel Hill.

   Design and materials. Sixty critical items and their antonym cues were selected from materials used by Jacoby (1983). The cues were unambiguous in meaning, and the target items varied in length from 4-6 letters. Thirty six of the sixty target items were indexed as high frequency by Thorndike and Lorge (1944); the remaining 24 target items were indexed as occurring 23.2 times per million (Kucera & Francis, 1967).

   The antonym pairs were divided randomly into four sets of fifteen words, which were then assigned within-subjects (and counterbalanced between-subjects) to the following four study conditions: hear-no-context, in which the target item was presented aurally following a visual series of Xs (e.g. XXXXX – "cold"); hear-context, in which the target item was presented aurally following a visual presentation of the antonym cue (e.g. hot – "cold"); generate, in which the antonym cue was presented visually followed by a series of question marks (e.g. hot -?????) ; and critical new, in which neither member of the pair was presented at study. The

between-subjects counterbalance produced four possible study lists, so that each set of fifteen items belonged to each of the four possible conditions an equal number of times across subjects. The study list was randomly ordered with the constraint that any given condition was not presented more than two times consecutively.

One hundred twenty two additional words were selected from the Kučera & Francis (1967) word frequency index, 60% of which were indexed at >200 and 40% were indexed between 100 and 200. Sixty of the items were extracted from this set for a pilot calibration task, which determined 5.18:1 as the appropriate white noise-to-average target decibel ratio which would yield on average 30-40% baseline correct. This pilot-tested ratio was used to create each of the target/white noise files and was selected for use for all participants. Of the remaining 62 items from the frequency-indexed set, 2 were used as buffer items at study, and 60 were used as filler items on the perceptual identification test, for a total of 120 items on the test (including the 60 critical items). All critical, filler, and practice items were recorded in the same voice (that of the female experimenter) and were volume-matched using the Goldwave recording software program. All items were pilot-tested for baseline clarity before being masked by white noise. List order on the test was the same for all participants.

Procedure. Participants were tested individually in a quiet, enclosed computer cubicle. After obtaining informed consent to participate, the experiment was described to each participant as being concerned with attention, problem solving, and words and their

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meanings. Two buffer trials preceded all critical trials. Each trial of the study phase began with the presentation of the cue word (or Xs in the no-context condition) for 3 seconds. In the hear condition, this was followed by an aural presentation of the target word over headphones. Participants were instructed to repeat aloud the spoken item. In the generate condition, the cue word was followed by a (visual) series of Xs; participants were instructed to generate the antonym of the presented cue and say it out loud. In all conditions, continuation onto the next trial was self-paced by pressing the enter key after writing the target word. The experimenter followed along to ensure adherence to the study instructions. Errors in generation were tracked but no feedback was provided to the participant.

Following the study task, participants were given two distractor tasks. In the first, they were given 3 minutes to complete as many of 40 arithmetic problems as they could without writing any intermediate calculations. They were instructed to complete each problem to the best of their ability, and were told that they could skip items and return to them at the end if time remained. At the end of three minutes, participants were administered the second distractor task, in which they were instructed to complete as many of 80 word stems as they could in 3 minutes with names of cities in the United States. Again, they were told to complete the task to the best of their ability and that they could skip items and return to them if time remained.

Following the distractor tasks, participants completed the auditory perceptual identification task (PI), in which items were presented through a computer program. Participants listened to each item presented over headphones and were instructed to try to identify each word out loud. The experimenter followed along with the participant and privately tallied which words were identified correctly. Continuation onto the next item was self-paced by pressing the enter key.

Following perceptual identification, a questionnaire was administered to assess the extent of awareness of item overlap between the study and test portions of the experiment. Those who reported awareness of the connection were asked whether they consciously attempted to think back to the study list in order to improve performance on the final task. Performance was later compared between those who did and did not report awareness, so as to test for the possible influence of explicit contamination. (See Appendix A for the awareness questionnaire).

Results

Memory performance on the perceptual identification task was assessed with the priming measure, defined as the proportion of old items identified relative to the proportion of critical new items identified. Priming scores were submitted to a one-way ANOVA, using encoding condition as a within-subjects factor. This assessed whether the generation manipulation affected priming. A significant effect was followed with planned comparisons between each pair of encoding conditions. Finally, priming scores in each encoding

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condition were submitted to a t-test to determine if the scores were significantly greater than 0 (that is, to determine if priming was found in each condition). An alpha level of α = .05 was set for all analyses.

At study, 99% of the items from the hear-no context and hear-context conditions were repeated correctly; 90% of items in the generate condition were generated correctly. Mean test performance for items from each encoding can be found in *Table 1.* There was a significant main effect of encoding condition, F (2, 70) = 4.117, MS_e = .017, indicating that priming scores differed among encoding conditions. Contrasts revealed that priming in both the hear no-context condition and hear- context condition was greater than priming in the generate condition (t(35)=2.460, and t(35)=2.676, respectively); these results indicate a reverse generation effect on auditory perceptual identification. A similar difference was found when scores from the hear conditions were compared to generated items conditionalized on whether each item was generated correctly at study (t(35) = 2.378). Perceptual identification of items from the hear no-context and hear-context conditions did not differ from each other, |t|<1.

Relative to baseline (the identification of new words), priming was demonstrated in the hear no-context condition (t(35)=2.748) and in the hear-context condition (t(35)=2.071). No priming was demonstrated in the generate condition, |t|<1.

Discussion

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The results from Experiment 1 fit well within the predictions of transfer appropriate processing. Words from the generate condition produced less priming than words from either of the hear conditions, demonstrating a reverse generation effect.

The items from both the hear-no-context and hear-context conditions were presented to the subject aurally both at study and at test, and as such it is not necessarily surprising that they produced similar amounts of priming. However, it is still important to compare the two hear conditions, so as to make sure that the antonym cue implemented in the hear-context condition did not change the effect. The hear conditions did not significantly differ from each other, a result that differs slightly from Jacoby (1983), in which priming in the read context condition was intermediate to levels of priming in the read-no-context and generate conditions. This slight difference will be discussed in more detail later. The fact that Experiment 1 produced a qualitative replication of Jacoby's (1983) results indicates that the functional dissociation between explicit and implicit memory produced by generation is not limited to the visual domain.

Subjects were also evaluated on two questions intended to tap into any potential explicit contamination. Twenty-nine out of the 36 subjects indicated that they had realized during the test that some of the items during the perceptual identification task had been presented at study; however, only eleven of these twenty-nine reported an explicit retrieval strategy. Using awareness as a between-subjects factor, there was no interaction between encoding

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condition and awareness of the connection between study and test portions of the experiment, $F < 1$. Further, there was no interaction between encoding condition and the reported use of explicit retrieval in PI, $F<1$. These results indicate that the above pattern of priming performance did not depend on whether the participant indicated awareness of study goals.

These nonsignificant interactions were not unexpected, even despite the large number of subjects who indicated test awareness. Several prior studies have demonstrated that test- aware and test-unaware subjects show similar amounts of priming. Bowers & Schacter (1990), for instance, found on (visual) word stem completion that test-unaware subjects demonstrated the same level of priming as subjects who were specifically informed by the experimenters before the completion test that some of the stems would be the same words as had been presented at study.

However, it is possible (as also acknowledged by Bowers & Schacter) that a post-test awareness questionnaire is not a sufficient method of assessing intentional retrieval strategies during an implicit test, as response may be influenced by a number of factors (including the questionnaire process itself). This is one reason why Experiment 1a was implemented, which examines the effect of Experiment 1's study manipulation on an auditory explicit test.

CHAPTER VI

EXPERIMENT 1A

As stated, the results of Experiment 1 were consistent with the predicted reverse generation effect on auditory perceptual identification. Before generalizing these results to other auditory priming tasks, it is important to demonstrate that a positive generation effect can be found on an auditory explicit task. On explicit tests such as recall and recognition, the positive effects of generation relative to perceptual tasks such as reading have been widely demonstrated in the visual domain (e.g. Slamecka & Graf, 1978; Jacoby, 1983. For a review, see Mulligan & Lozito, 2004). Experiment 1a was implemented in order to test the effect of generating from antonyms on an auditory recognition task, thereby to find out if the classic functional dissociation produced by generation is replicated in the auditory domain. Finding a positive generation effect on auditory recognition will also help to argue against a claim that explicit contamination may have influenced priming performance on the implicit test.

Method

Participants. Twenty-four undergraduate participated in partial fulfillment of a course requirement in an introductory psychology course at the University of North Carolina at Chapel Hill.

Design and Materials. Study materials for this experiment remained identical to those used in Experiment 1. Perceptual identification at test was replaced with the auditory recognition test, consisting of 60 critical items (forty-five items presented at study mixed with fifteen new items). As in Experiment 1, items were counterbalanced across the three study conditions and the new condition sound files were presented in their clear, complete form during the test. (Sound files from the hear condition were the same at test as at study.)

Procedure. Only the test portion of Experiment 1a was different from that in Experiment 1. Participants listened to each item presented sequentially over headphones. Participants were told that some of the presented items were previously on the study list and that other items would be new. After listening to each item, they were instructed to indicate whether the item was old or new by pressing the letter "o" if the word was from the study list and the letter "n" if the word was not from the study list. Instructions emphasized that words previously heard or previously generated should both be considered old. If the participants were not certain, they were instructed to make their best guess. They were not allowed to skip any items. Each subsequent item was presented 500ms after a letter choice was pressed. Responses were tracked by the computer and no feedback was provided to the participant.

Results

Hits and false alarm rates for each encoding condition are presented in Table 2. Accuracy performance on the recognition test

was assessed with d', the standardized difference between hits and false alarms for items in each encoding condition. Performance was highest for items from the generate condition (d' = 2.10), was intermediate for the hear-context condition (d' = 1.72), and was lowest for the hear-no-context condition (d' = 1.32). Accuracy scores were submitted to a one-way ANOVA, using encoding condition as a within-subjects factor, in order to test whether the generation manipulation affected auditory recognition. There was a significant main effect of encoding condition, F (2, 46) = 14.650, MS_e = .249. Follow-up paired sample t-tests indicated a significant generation effect, with the generate condition significantly higher than hear-context (t(23) = 2.78), which was significantly higher than hear-no-context (t(23) = 2.43).

Discussion

The described generation effect on auditory recognition replicates that found by Jacoby (1983), and serves to support functional independence between explicit and auditory implicit memory. Given the opposite pattern of performance for the implicit and explicit tests, the results provide additional evidence against explicit contamination in the implicit tests. If consciously controlled processes had been used to aid performance on perceptual identification, they would have benefited the items from generate condition. However, as described earlier, generation produced no priming in Experiment 1.

CHAPTER VII

EXPERIMENT 2

To gain a broader understanding of priming in the auditory domain, it is important to generalize the results of Experiment 1 to other implicit tests. Experiment 2 extended the analysis of generation effects to auditory word stem completion (WSC). Auditory word stem completion often produces greater priming than does auditory perceptual identification (e.g. in Mulligan, Duke & Cooper, in press); this implicit test thus may allow for greater sensitivity to detect smaller priming differences among encoding conditions.

The extension to WSC was also motivated by differences occasionally found following generation between visual PI and WSC (e.g., Schwartz, 1989), and by differences found between these two tests in other auditory-priming experiments (e.g., Pilotti et al., 2000a). Consequently, it is important to determine if the results of Experiment 1 generalize to other auditory priming tasks.

Method

Participants. Twenty four undergraduates participated in partial fulfillment of a course requirement in an introductory psychology course at the University of North Carolina at Chapel Hill.

Design and materials. The study phase and the distractor tasks were identical to those used in Experiment 1. Perceptual identification at test was replaced by word-stem completion. Items

and list order at test otherwise remained the same. The originally recorded and pilot-tested items (not masked by noise) were changed so that only the first one or two phonemes of the item could be heard. As is typical for WSC, the stems were constructed to allow for multiple legitimate completions. The remainder of the sound file was erased and replaced with silence using the Goldwave recording software program. Word stems were pilot-tested to produce 30-40% accuracy in baseline critical response.

Procedure. Only the test procedure in Experiment 2 was different from that in Experiment 1. Participants listened to each word-stem presented over headphones and were instructed to fill in each stem with the first word that came to mind that could complete the stem. If they were unable to think of a word that could complete the stem, they were instructed simply to move on to the next word stem. As in Experiment 1, continuation to the next item was self-paced by pressing the enter key.

Results

Memory performance on word stem completion was assessed with the same priming measure as in Experiment 1.

At study, 100% of the items from the hear-no-context and hear-context conditions were heard correctly; 94% of items in the generate condition were generated correctly. Mean test performance for items from each encoding condition is included in *Table 1*. There was a significant main effect of condition, F (2, 46) = 7.798, MS_e = .021, indicating that priming scores differed among encoding conditions. Contrasts revealed that priming was greater in both the

hear no-context and hear-context conditions than in the generate condition (t(23)=4.269, and t(23)=2.558, respectively); these results indicate a reverse generation effect on auditory word stem completion. A similar difference was found when scores from the hear conditions were compared to generated items conditionalized on whether each item was generated correctly at study (t(23) = 3.581). The hear no-context and hear-context conditions did not differ from each other, $|t|$<1.

Relative to baseline (the likelihood of completing the stems with unstudied critical items), priming was demonstrated in the hear no-context condition (t(23)=5.075) and in the hear-context condition (t(23)=3.505). No priming was demonstrated in the generate condition, $|t|$<1.

Lastly, eleven out of twenty-four subjects indicated awareness of the connection between the study and test portions of the experiment, and zero subjects claimed explicit retrieval. There was no interaction between encoding condition and awareness, F < 1. This indicates that the above pattern of priming performance did not depend on whether the participant was conscious of the connection between study and test items; priming performance therefore is unlikely to have been contaminated by explicit processes.

Discussion

Experiment two revealed the same pattern of priming performance as did Experiment 1. Performance for the hear conditions was significantly higher than the generate condition, demonstrating a negative generation effect. As expected, overall priming scores were

higher for WSC than for PI, allowing greater sensitivity to detect small differences. Still, no significant priming was found for items in the generate condition, and no significant difference was found between the two hear conditions, providing further evidence of these as reliable effects.

Some studies have demonstrated differences between auditory PI and WSC in their sensitivity to fine-grained perceptual information (e.g. Pilotti et al., 2000a) or between visual PI and WSC after some generation tasks (e.g. Schwartz, 1989). However, the vast majority of studies have shown that the negative effect following semantic generation can be generalized across implicit tests (see Roediger & McDermott, 1993). The present experiment fits with this body of literature. It also helps to motivate Experiment 3, which was intended to generalize the results of Experiments 1 and 2 to a different semantic generation task.

CHAPTER VIII

EXPERIMENT 3

Experiment 3 examined the effect of generating from definitions on auditory WSC. In visual priming, antonym generation consistently produces a negative generation effect (for a review, see Roediger & McDermott, 1993). However, other semantic generation tasks (such as generating from a definition) have produced somewhat mixed results. Most studies have reported a negative generation effect, consistent with transfer-appropriate processing and with the results of antonym generation, but some studies have reported no effect (e.g. Masson & MacLeod, 1992). Consequently, it is critical to determine if the negative generation effect found in Experiments 1 and 2 generalizes to other generation manipulations.

Method

Participants. Thirty-six undergraduates participated in partial fulfillment of a course requirement in an introductory psychology course at the University of North Carolina at Chapel Hill.

Design and materials. The basic experimental design and the WSC test from Experiment 2 remained the same in Experiment 3. However, the study design and materials changed: Antonym pairs were replaced with items and their definitions. Simple, unambiguous definitions to 80 critical items were created by the experimenter and were pilot-tested; each item was generated correctly at least 88% of the time

in the pilot study. All items were one syllable and 5 letters in length, and their mean frequency was indexed as 43.31, range 20-88 (Kučera & Francis, 1967). The 80 items were randomly divided as follows: First, the items were divided into two sets of 40 for the old-new counterbalance. Twenty words on each study list were presented as hear-in-context: Targets were presented aurally following the visual presentation of the definition (e.g. move to music – "dance"). The remaining 20 were in the generate condition, in which words were generated from visual stems following a definition cue (e.g. move to music – da). In total, this design produced 4 possible study lists, which were randomly assigned to subjects. As in Experiment 1, the study list was randomly ordered with the constraint that any given condition was not presented more than two times consecutively.

The word stems for the test portion were created the same way as in Experiment 2. A total of 115 items was included on the test: 80 critical items (40 old and 40 new) and 35 filler items, which were similar in length and frequency to the critical items.

Procedure. The procedure was the same as Experiment 2 with the following modifications to the study phase: In the hear condition, participants were instructed to read the definition silently, listen to the presented word that corresponds to the definition, and repeat the spoken word out loud. In the generate condition, participants were instructed to read the definition silently, generate a word that corresponds with the definition and that begins with the presented letters, and say the generated word out loud. Two practice

items (one of each study instruction) preceded critical items. As in Experiments 1 and 2, the experimenter followed along to ensure adherence to the study instructions. Errors in generation were tracked but no feedback was given to the participant. All remaining portions of the experiment were identical to those used in Experiment 2.

Results

Memory performance was assessed with the same priming measure as in Experiments 1 and 2.

At study, 100% of the items from hear condition were heard correctly; 92% of items in the generate condition were generated correctly. Mean test performance for items from each encoding can be found in *Table 1.* There was a significant main effect of condition, $t(31) = 3.08$, indicating that priming scores differed between the two encoding conditions. This result indicates a reverse generation effect on auditory word stem completion. A similar difference was found when scores from the hear conditions were compared to generated items conditionalized on whether each item was generated correctly at study ($t(31) = 2.38$).

Relative to baseline (the likelihood of completing the stems with unstudied critical items), priming was demonstrated in the hear condition ($t(31) = 6.29$) and in the generate condition as well ($t(31) = 2.93$).

Lastly, eighteen of thirty-two subjects indicated awareness of the connection between study and test, and two out of thirty-two claimed to have thought about the prior study items in order to help

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complete the word stems. There was no interaction between encoding condition and awareness, $F < 1$, which indicates that the pattern of priming performance did not depend on whether the participant indicated awareness of the connection between study and test. Furthermore, generation consistently enhances explicit memory, so if explicit contamination were a problem, we would see a positive generation effect. Thus, as in Experiments 1 and 2, priming performance is unlikely to have been contaminated by explicit processes.

Discussion

Experiment 3, like Experiments 1 and 2, fits with the initial predictions. The generate condition produced significantly lower priming on the auditory implicit test than the hear condition, demonstrating that a negative generation effect can be generalized to semantic generation tasks other than antonyms. One minor difference is that in Experiment 3, significant priming was produced for items in the generate condition. This result is not unprecedented; several studies have shown that generation can produce significant priming (e.g. Schwartz, 1989). The key result here is the increase in priming for the heard items relative to the generate items, demonstrating the expected reverse generation effect.

CHAPTER IX

GENERAL DISCUSSION

In summary, Experiment 1 compared hearing words without context, hearing words in a meaningful context, and antonym generation on auditory perceptual identification. A reverse generation effect was found, with larger amounts of priming in the hear conditions relative to the generate condition. This negative generation effect was generalized to auditory word stem completion in Experiment 2, and to generation from definitions in Experiment 3. In both of these experiments, priming in the hear conditions was significantly greater than priming in the generate condition.

A key goal of Experiments 1 and 1a was to find out if Jacoby's (1983) classic dissociation between explicit and implicit memory could be replicated in the auditory domain. As described, a negative generation effect was found on auditory perceptual identification, with words from the hear conditions producing larger amounts of priming than the generate condition, which actually produced none. In contrast, Experiment 1a compared the same study manipulations on auditory recognition, and produced the opposite pattern of results, a positive generation effect: Words from the generate condition produced higher accuracy than words from the hear conditions. This primary result closely resembles Jacoby's dissociation. Taken

together, the three experiments indicate a negative generation effect on auditory implicit memory, and a positive generation effect on auditory explicit memory. This anticipated dissociation is consistent with the described bodies of research on the effects of generation on explicit and implicit memory.

The results of the present experiments additionally show that generation can join other manipulations within the literature that demonstrate important similarities between visual and auditory priming. As described earlier, explicit memory has been dissociated from implicit memory in both the visual and auditory modalities. Amnesic patients and older adults often demonstrate impaired performance on explicit tasks compared with largely intact performance in both visual and auditory implicit tasks (e.g., Schacter, Church & Treadwell, 1994; Sommers, 1999). Visual and auditory priming also have shown sensitivity to changes in the perceptual features of the target stimuli, a manipulation which typically has little or no effect on tests such as recall and recognition (e.g., Church & Schacter, 1994). The current studies demonstrate that semantic generation also serves as a functional dissociation between explicit and auditory implicit memory. The effect of generation on implicit tests in the visual modality has often been used to classify them as perceptually-driven; the dissociation found on auditory PI and WSC here supports the classification of these tests as perceptual as well. Doing so may support a more general functional overlap between visual and auditory priming.

This overlap in function between auditory and visual priming also fits with findings from some neuroimaging studies. Badgaiyan, Schacter & Alpert (1999), for instance, examined PET images for within-modal auditory word stem completion. Neuroimaging often demonstrates a decrease in blood flow in particular brain regions following repeated stimuli relative to new stimuli. This neural correlate of priming is typically interpreted as reflecting increased efficiency in re-processing a stimulus. In visual priming, the priming-related decrease is typically found in the extrastriate cortex (for a review, see Schacter, Wagner, & Buckner, 2000). Interestingly, auditory priming shows a similar pattern, with blood flow decreases in the extrastriate cortex (e.g., Schacter, Badgaiyan & Alpert, 1999). Behaviorally, auditory and visual priming often show high amounts of modality specificity, for instance in priming reductions found after study-test changes in the perceptual features of the stimulus. However, such neuroimaging findings indicate that at least some perceptual priming functions may be amodal, and may support a functional overlap between priming in the visual and auditory domains.

Importantly, the present results also fit well within transfer-appropriate processing. This theoretical account predicts that perceptual retrieval tasks will benefit from perceptually-driven encoding tasks, and will be largely insensitive to conceptual encoding manipulations. Consistent with this prediction, auditory perceptual identification and word stem completion demonstrated the

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best performance for items that had been processed aurally at study, and did not benefit from semantic processing at study.

Although the key results of the current studies can be placed back into the described theoretical context and support the many established similarities between visual and auditory priming, there are interesting differences to consider. One difference between the present results and those found by Jacoby relates to the role of the hear-context condition in both the implicit and explicit tests. The original results placed the three encoding conditions across step-wise levels of performance, with the read-context condition producing amounts of both priming and recognition accuracy intermediate to the generate and the read-no context conditions. In the present experiments, however, the hear-context condition acted similarly to the hear-no context condition on the implicit test, and in contrast acted similarly to the generate condition on the explicit test. These results thus demonstrate an interesting dissociation between hear-context and hear-no context on auditory implicit and explicit tests.

There are several possible implications of this result. Especially given that the generate condition produced zero priming, one possibility is that auditory PI may be so data-driven that performance depends entirely on whether or not the item was heard at study, independent of the presence of contextual or semantic information. In their comparison of auditory implicit tests, Pilotti et al. (2000a) had found auditory PI to be the most sensitive to changes in perceptual features from study to test; this provides

additional evidence toward high amounts of data-driven processing required in this particular task.

A competing explanation for the relatively high priming in the hear-no-context condition comes from the possibility that, although they appear similar in many ways, the auditory version of perceptual identification may rely on a different degree of perceptual processing than its visual counterpart. According to Pisoni's (1996) analysis of auditory PI, noise tends to mask consonants more so than vowels, an artifact that might selectively affect auditory processing in a way that is not relevant to reading briefly presented words. Pisoni also argues that identifying words masked in noise reflects a combination of bottom-up acoustic processing as well as top-down lexical processing. This analysis could explain why, relative to visual priming studies, performance for words in the hear-context condition may have been bolstered.

The simplest explanation of why the hear-context condition produced similar performance to the generate condition on the explicit test is a methodological one. In visual study formats, a target word and its contextual cue are presented alongside each other, allowing the subject to read and process them virtually in parallel. Parallel presentation in the auditory modality would be distracting (or confusing), however, and as such there was a necessary time delay between the presentation of the cue and the target. Though brief, the delay did potentially allow the participant enough time to have generated the target item before hearing it, especially given such predictive generation cues as

antonyms. Jacoby did initially demonstrate in one experiment that generating words produced the same amount of priming on (visual) PI as did reading the word directly after it had been generated. He concluded that under such conditions, reading in context may require as little perceptual processing as generating it. This account fits with the results incurred by the procedural requirements in the auditory study task.

As reviewed earlier, the TAP account predicts that memory will benefit to the extent that encoding and retrieval require similar processing. By this account, it alternatively may not be the encoding task that produced the difference but rather the processing requirements of the retrieval task. Although Experiment 1a is useful for demonstrating a dissociation between explicit and implicit memory in the auditory modality, it is plausible that auditory PI and auditory recognition differ from each other in ways or processes other than conscious access to the study items. Schacter, Bowers & Booker (1989) had proposed that the key criterion distinguishing implicit and explicit tests should be the intention to retrieve and think back to the study episode, and that other external cues should remain constant. Because the results of the current study fit with the prior theoretical predictions, it is unlikely that having compared auditory recognition with word stem completion is problematic in this regard. However, it may be worthwhile in a follow-up experiment to make sure that there were no relevant context effects here. For instance, it may be informative to test whether the hear-context condition acts more similarly to the

generate condition or to the hear-no-context condition on an auditory cued recall task, in which the same word stems are heard in the both the explicit and implicit tests, and in which the only difference is whether or not the subject is asked to think about the study list in order to perform the task.

Across Experiments 1 and 2, no priming occurred in the generate condition, a result that merits consideration given that subjects generated the critical items out loud. Because subjects repeated targets aloud in all conditions, this procedural detail does not confound the differences between conditions on the implicit tests. However, this is an interesting result because it can not be fully explained by the mismatch in the perceptual stimulus between the recording and the subject's own voice. The perceptual mismatch, of course, was maximized due to the fact that subjects wore headphones, thereby muffling the sound of their voice. In several prior studies, however, even on perceptually-driven tests, some priming has been shown to occur when the surface-level features of the stimulus does not match from study to test. Church & Schacter (1994) demonstrated some priming when fundamental frequency of the auditory stimulus changed. Furthermore, Pilotti et al. (2000b) found reduced but still significant priming when subjects simply imagined the word being spoken but did not actually hear them. The result in the current study, therefore, has interesting possible implications for the auditory processing of self-produced stimuli. If the perceptual mismatch between study and test cannot fully explain the lack of priming, then other factors could be considered, such as the extent

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to which subjects attend to self-produced stimuli. Although the effect is not as great as in explicit memory, Mulligan et al. (in press) found that some divided attention tasks do reduce auditory priming.

There are several possible directions for further research. One issue worth considering is the possibility that some implicit tests, such as word stem completion, may reflect and benefit from multiple processes. For instance, according to Nicolas & Tardieu (1996), WSC may on the one hand benefit from perceptual processing at study because it relies on speed for successful completion, and perceptual representations of stimuli may become available first. However, with additional time allowed, conceptual processes may emerge. Nicolas & Tardieu asked subjects to read words or to generate them by transposing anagrams, a nonsemantic generation task. When participants were later instructed to complete word stems with the first four words that came to mind, perceptual processing at study benefited the first words, but a generation effect was found on the latter three words, where more effort was required to complete them. In another example, Gibson & Bahrey (2005) found reduced cross-modal priming on auditory word fragment completion, demonstrating its reliance on some perceptual processing. However, further experiments demonstrated weaker but still significant priming on auditory WFC after targets were implied but never heard (e.g. the target *refrigerator* was presented as a fragment at test after hearing at study "The food was put away in the appliance"). Auditory WSC and WFC, then, may operate under at least some non-perceptual processes.

If auditory word stem completion reflects multiple processes, this may help explain why generation did produce some priming in Experiment 3, in which the generate condition may have encouraged both perceptual and conceptual processing. Identifying the relative contributions of perceptual and non-perceptual processes in specific auditory implicit tests will be important for any future direction of auditory priming studies.

Similarly, it may be worthwhile to investigate of how lexical analysis contributes to auditory priming tasks. Rueckl (1990) found in the visual modality that priming was produced among items that were similar in orthographic form but did not share lexical properties. Weldon (1991) also suggested that lexical processing may be a necessary precursor to perceptual priming in the visual modality. The present experiments did not examine whether surface similarity was sufficient to produce priming on a perceptual task. A future task might investigate whether priming is produced among auditory homophones, in which two words with different conceptual properties are perceptually identical (e.g. plane and plain); this could help demonstrate whether lexical access to the target word may be necessary before perceptual priming can occur in the auditory domain.

Another possible direction is to examine the effect of non-semantic generation tasks on auditory implicit tests. One motivation for this direction comes from Mulligan's (2004) study of explicit memory for context detail, in which he found a generation effect for item memory, a negative generation effect for color of

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the items, and no difference between encoding conditions for spatiotemporal location. Mulligan found that transfer-appropriate processing could best explain this set of results; the read condition required greater perceptual processing of the target word, which led to better encoding of perceptual details about the target stimulus, such as its color. Location, however, was an external detail (not a perceptual detail of the item itself). Follow-up research was conducted on perceptual generation tasks, which by the described account should enhance memory for item and context. After subjects generated from anagrams (which would be considered visual processing), they demonstrated superior item memory than for read items, but equivalent perceptual memory. However, when subjects generated from rhymes (phonological processing), they demonstrated superior item memory but worse perceptual memory. A perceptual, non-visual, generation task therefore produced results more typical of semantic generation. These results help to motivate the question of whether sound-based generation tasks (such as generating from rhymes or other phonological information, which would be considered nonsemantic but also nonvisual) could enhance priming on an auditory priming test.

APPENDIX

Awareness Questionnaire:

1. What do you think was the purpose of the task you just completed?

2. Did you think there was anything unusual about the words that were presented?

3. Did you notice any connection between the words you heard earlier and the task you just performed?

4. If the subject says 'yes.', then ask: '<u>What</u> did you notice?'

5. Were you aware of this connection at the time you were identifying the words, or did you only become aware of it after I began to ask these questions?

6. If the subject noticed that some of the responses corresponded to the words presented earlier, ask: 'Did you consciously try to use words from the earlier part of the experiment to help you identify words presented in the last part of the experiment?'

NOTE: YOU ARE NOT FINISHED WITH THE QUESTIONNAIRE UNTIL YOU, THE EXPERIMENTER, CAN ANSWER THE FOLLOWING QUESTIONS.

1. Was the subject aware, at the time, of the connection between the two parts?   Yes / No   (circle one)

2. Did the subject consciously try to use the words from the earlier part as responses in the last part?
                                Yes / No   (circle one)

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Table 1:

Mean Proportion Correct (and Standard Deviation)

as a Function of Encoding Condition across Experiments 1-3

Encoding Condition

	Test	HNC	HC	GEN	NEW
Experiment 1	PI	.52 (.15)	.52 (.13)	.45 (.11)	.44 (.15)
Experiment 2	WSC	.46 (.12)	.42 (.16)	.30 (.15)	.31 (.14)
Experiment 3	WSC	---	.48 (.12)	.39 (.11)	.31 (.08)

Table 2:

Recognition Performance across Conditions in Experiment 1a

Encoding Condition

	HNC	HC	GEN	NEW (FALSE ALARM RATE)
Proportion Old	.55	.70	.80	.16
d′	1.32	1.72	2.10	