

AGING AND TEXT-SPECIFIC IMPLICIT MEMORY

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This study investigates the effects of aging on text-specific implicit memory. In Experiment 1, young and elderly subjects had to read three times in succession two different texts. Results show that text rereading facilitation is similar in young and elderly subjects, and that this facilitation is text specific. The purpose of Experiment 2 was to distinguish between the respective roles of perceptual and conceptual priming in young and elderly subjects in text rereading facilitation. The procedure was similar to Experiment 1, except that two different meaningless texts with exactly the same words were used. Here, the results show that, for the two groups, the first reading of the second text is faster than the first reading of the first text, which confirms the importance of perceptual priming in text rereading facilitation, but not as fast as the third reading of the first text. So, the data suggests that the combination of a perceptual and a low-level conceptual (associations between words) priming effect could underlie text rereading facilitation, and that these effects are preserved in aging.

Introduction

It is well documented that elderly adults perform poorly on explicit tests of memory, such as recall or recognition, which require a deliberate recollection of specific episodes (Van der Linden, 1994). However, when young and elderly adults are compared on implicit (or indirect) measures of memory, which do not involve deliberate or conscious recollection, age differences are generally small and unreliable (Graf, 1990; Van der Linden, 1994). In implicit memory studies, the most investigated phenomenon has been perceptual priming. Priming refers to the facilitatory or biasing effect that exposure to a stimulus has on subsequent processing of the same stimulus. Memory for an item is inferred from changes in the efficiency with which the item is processed when it is repeated or when the subject is given appropriate cues. On perceptual priming tests, a target item presented at study is cued at test by its fragmented or "perceptually degraded" form. One prototypical situation is the perceptual identification task. In a first step (study phase), subjects read a list of words. After a delay, words that were previously read and new words are briefly presented, and subjects have to identify them (test phase). A priming effect is observed when the identification thresholds for the studied words are lower than the thresholds for the new words. This priming effect refers to a facilitation of the perceptual identification of a stimulus due to a previous encounter with

that stimulus.

Beside perceptual priming, some studies have also shown the existence of a conceptual priming effect. On conceptual priming tests, the cue at test is conceptually related to the studied stimulus word, in the absence of any perceptual similarity between them.

Several studies have reported no significant difference between young and elderly subjects on various repetition priming tasks such as word-fragment completion (Light, Singh, & Capps, 1986), perceptual identification (Light & Singh, 1987) and picture naming (Mitchell, 1989; Mitchell, Brown, & Murphy, 1990). All these tasks can be considered to be primarily perceptual repetition-priming tests in that the retrieval cue provided at the test specifies the perceptual form of the studied stimulus. However, in a recent meta-analysis of the repetition-priming effects in the elderly, La Voie and Light (1994) concluded that, although small, an age difference in the magnitude of repetition priming for verbal material can be found when results are aggregated across experiments. Nevertheless, these age differences remain smaller than those for direct measures of memory. Relating to this, it should be noted that studies on word-stem completion (a commonly used perceptual priming test) in elderly people have produced inconsistent results, some of them reporting normal while others impaired performance (Chiarello & Hoyer, 1988; Davis, Cohen, Gundy, Colombo, Van Dusseldorp, Simolke, & Romano, 1990; Hultsch, Masson, & Small, 1991; Java & Gardiner, 1991; Light & Singh, 1987). These discrepancies have been interpreted as suggesting that word-stem completion may have a strategic, lexical or conceptual search component not found in more perceptual priming tasks such as fragment completion or perceptual identification (Moscovitch & Winocur, 1992). According to Moscovitch and Winocur, age-related differences on word-stem completion may be related to impaired frontal-lobe function in the elderly. In line with this hypothesis, Winocur and Diesman (in Moscovitch & Winocur, 1992) observed that the age-related deficits in word-stem completion were correlated with performance in verbal fluency and the WCST, two standard psychometric tests of frontal function.

Evidence concerning the preservation of conceptual priming in the elderly is more sparse (see Kausler, 1994, for a review). Light and Albertson (1989) found that prior study of a list of words containing examples of categories (such as vegetables or birds) increased the probability that young and elderly subjects would later mention these examples when asked to generate category members. Although the generation task clearly has a strategic search component, priming of category exemplars did not vary significantly with age. In contrast, elderly adults produced significantly fewer category members in an explicit cued-recall test. In a recent study, Isingrini, Vazou, and Leroy (1995) reached the same conclusions using the same paradigm with very old adults. On the other hand, some studies have found divergent results with conceptual priming tasks

for new associations (Howard, Fry, & Brune, 1991; Van der Linden, Bruyer, & Dave, 1992). Howard (1988; Howard et al., 1991) suggested that, beside a long delay between study and test, a single material presentation and the test order (backward vs. forward associations), less elaboration-inducing study conditions could be an important variable leading to an age effect in conceptual priming. Nevertheless, Van der Linden et al. (1992) showed age differences in a conceptual priming task for new associations involving a profound encoding level.

Considered overall, and even if most studies suggest intact priming effects in the elderly, data available on implicit memory measures does not clearly show the absence of any age differences. The purpose of the present research was to provide further evidence on priming in the elderly. Young and elderly adults were compared on another implicit memory task, text rereading facilitation, which was successfully used in amnesic patients (Musen, Shimamura, & Squire, 1990) and in Alzheimer patients (Monti, Gabrieli, Wilson, & Reminger, 1994). Musen et al. (1990) and Monti et al. (1994) used the same rereading paradigm: their subjects had to read two texts three times in succession, each as quickly as possible. The main result of the two studies was that of a normal reading facilitation across the three successive trials for amnesic and for Alzheimer patients. This can be taken as evidence of implicit memory, and so the task appears to be relevant for studying implicit memory.

So, our main purpose was to investigate implicit memory in elderly subjects with the rereading paradigm used by Musen et al. (1990) and by Monti et al. (1994). A normal reading facilitation would indicate a normal priming effect in elderly subjects. In Experiment 1, we investigated whether elderly subjects would improve their reading speed at the same rate as young subjects. The purpose of Experiment 2 was to distinguish further between the respective role of perceptual and conceptual priming in young and elderly adults in text rereading facilitation.

Experiment 1

A rereading task similar to that used by Musen et al. (1990) was carried out by young and elderly adults. Subjects were asked to read two different stories, each one three times in succession. Facilitated reading speed would be reflected in progressively faster times for successive readings. If facilitated reading speed is specific to the practiced text, then the first reading of the second story should be slower than the third reading of the first story and at about the same speed as the first reading of the first story.

Subjects

Subjects comprised 16 young and 16 elderly adults. Young subjects (8 males and 8 females) were aged between 20 and 27 years (mean age = 22.5) with 15.6 years of education on average ($SD = 1.4$) and a mean score on the Mill Hill Vocabulary Test (French language version of the multiple-choice synonym subtest; Deltour, 1993) of 38 (maximum score: 44). The elderly subjects (9 males and 7 females) were healthy people living in the community (without any non-corrected visual difficulty), aged between 60 and 73 years (mean age = 66.2) with 16.8 years of education on average ($SD = 1.9$). Their mean Mill Hill score was 38.3. The vocabulary scores did not differ significantly across the two samples ($t(30) = -.403$).

Material and procedure

Two short stories were selected as the study material (212 and 214 words in length; see Appendix A). The two texts were excerpts from the *Reader's Digest* magazine and were printed in double spacing using the same margin width and print. The print size was large enough to avoid any perceptual difficulty for the elderly subjects (print size: 14 points). The Henry reading-easiness test scores (Henry, 1987) were 48 for the first story, and 52 for the second story.

Subjects were told that they would be asked to read stories several times and that they would then be asked questions about their content. Subjects then read each story aloud three times in succession. The order of the two stories was counterbalanced across subjects. Subjects were told to read the stories as quickly as possible but not so quickly that they would not understand what they were reading. The time needed to complete each reading was recorded by a stopwatch. After the third reading of the first story, subjects read aloud the second story three times following the same procedure. After the three readings of the second story were completed, subjects were given 10, three-alternative, forced-choice questions about each story.

Results

Figure 1 shows the mean reading times for young and elderly subjects. A $2 \times 2 \times 3$ ANOVA with age (young vs older adults), passage (first read story, second read story) and reading trial (reading trial 1-3) with repeated measures on the last two factors showed a significant effect of age ($F(1, 30) = 20.57, p < .0001$), a significant effect of repeated reading ($F(2, 60) = 96.39, p < .0001$), but no effect of story ($F(1,30) = 2.35, p > .10$) and no interaction (all F s $< 1.67, p$ s $> .20$).

Post hoc analysis (Scheffé test, $p < .05$) showed that for each group, the first

reading of the second story was accomplished at about the same speed as the first reading of the first story and was significantly slower than the third reading of the first story.

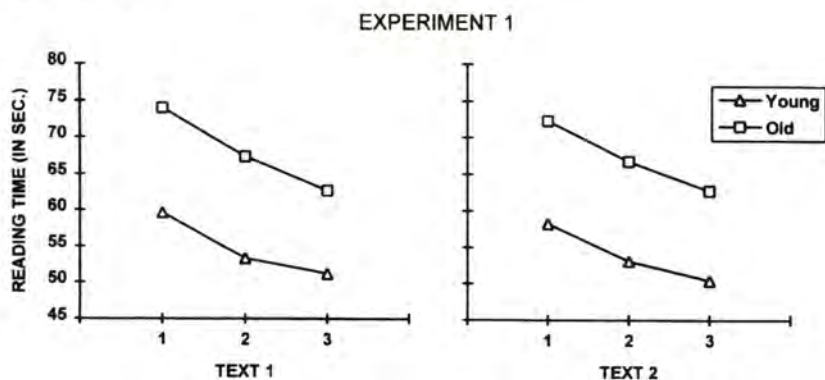


Figure 1. Mean reading times of young and old subjects for three successive reading trials (two meaningful texts).

Thus, older subjects read more slowly than young subjects but they improved their reading speed as much as young subjects (Figure 1). Furthermore, there was no transfer of reading speed from the first to the second story. However, young subjects performed better than the elderly subjects on the questions about story content: Story 1, 71.9% versus 56.2% ($t(30) = 2.21, p < .05$); Story 2, 76.9% versus 63.7% ($t(30) = 2.06, p < .05$).

These results indicate that reading facilitation is text specific, and that this facilitation effect is preserved in aging.

Experiment 2

Experiment 1 showed a similar rereading facilitation for young and older subjects. However, the source of this text-specific facilitation remains to be considered. The results of Experiment 1 suggest that this rereading facilitation is not due to a general reading-skill acquisition. Indeed, the facilitation effect was text specific in that it occurred for successive readings of the same text, but not from one text to another. Furthermore, Musen et al. (1990) reported a normal text rereading facilitation for amnesic patients who could not explicitly remember the texts. These results suggest that the ability to explicitly retrieve and become aware of the repetition is not a necessary condition for the rereading facilitation effects. Therefore, another possibility is that the rereading effect might be partly due to the priming of words (word-level explanation)

and/or associations in the text (text-level explanation). The word-level explanation suggests that rereading facilitation could be due to a perceptual priming effect for the words that have been repeated; each time an already encountered word is re-encountered, it is primed and processed more quickly. On the other hand, Monti et al. (1994) suggest a text-level account, which views the rereading effect as being mediated by new, text-specific associations constructed from each passage. These authors suggest two variants of this account: one based on low-level associations, where the observed learning may have reflected the implicit learning of new between-word associations, and one based on high-level associations between ideas that constitute a mental model of the text. This latter could account for priming in terms of an increased ease in reconstructing a mental model that has already been constructed during a previous reading.

Experiment 2 constitutes a first step to distinguish further between the respective roles of these perceptual and conceptual priming effects in young and elderly adults in text rereading facilitation. More specifically, could perceptual priming for isolated words be responsible alone for text rereading facilitation? And if so, should we observe differences between young and elderly subjects?

We asked young and elderly adults to read as quickly as possible three times in succession two different meaningless texts with exactly the same words. The fact that these texts were meaningless entails that high-level associations are at least difficult to construct, and that a mental model of the text should not be built up. In this case, only low-level associations between words and/or a perceptual priming effect would remain to account for a rereading facilitation. On the other hand, if transfer of the reading facilitation was observed from one text to the other, then the hypothesis of a perceptual priming influence on rereading facilitation would be confirmed. If the magnitude of this transfer is similar between young and elderly subjects, this could be considered as another argument for the preservation of a perceptual priming effect in the elderly.

Subjects

Two new groups of subjects were selected for Experiment 2. They comprised 16 young and 16 elderly adults. Young subjects (6 males and 10 females) were aged between 21 and 29 years (mean age = 25.18) with 16.4 years of education on average ($SD = 1.54$) and a mean score on the Mill Hill Vocabulary Test (Deltour, 1993) of 39.8 (maximum score: 44). The elderly subjects (4 males and 12 females) were healthy people living in the community (without any non-corrected visual difficulty), aged between 61 and 73 years (mean age = 67.5) with 14.6 years of education on average ($SD = 2.18$). Their mean Mill Hill score was 40.1. The vocabulary scores did not differ significantly across the two samples ($t(30) = -.381$).

Material and procedure

Two meaningless but grammatically correct texts were used (each one 217 words in length; see Appendix B). The original text was an excerpt from Rimbaud (*Poésies*; Paris: Presse Pocket, 1981). The first text used in Experiment 2 was constructed as follows: first, uncommon words of the original text were replaced with more common words; then, words were permuted from one sentence to another, in such a way that the text remained grammatically correct. The second text was constructed by permutating words of the first text. So, the two texts comprised exactly the same words, with each word appearing the same number of times in each text, but arranged in a different manner. The only words appearing in the same order in the two texts were the article-noun associations. The Henry reading-easiness test scores (Henry, 1987) were 53 for the first text, and 54 for the second text. The two texts were printed in double spacing using the same margin width and print. The print size was large enough to avoid any perceptual difficulty for the elderly subjects (print size: 14 points).

Subjects were told that they would be asked to read the texts aloud several times. They were also informed about the fact that the stories were meaningless (they were first asked to read an example, which contained none of the words present in the two texts). The order of the two stories was counterbalanced across subjects. The only constraint was to read the stories as quickly as possible. The time needed to complete each reading was recorded by a stopwatch. After the three readings of the first story, subjects were asked to read the second text in the same way.

Results

A $2 \times 2 \times 3$ ANOVA with age (young vs elderly adults), passage (first read text, second read text) and reading trial (reading trial 1-3), with repeated measures on the last two factors, showed a significant effect of age ($F(1, 30) = 6.82, p < .05$), indicating that young subjects read more rapidly than elderly subjects; a significant effect of repeated reading ($F(2, 60) = 146.73, p < .0001$); a significant effect of text ($F(1, 30) = 31.01, p < .0001$); an interaction between text and reading trial ($F(2, 60) = 19.49, p < .0001$); and an interaction between text, reading trial and age ($F(2, 60) = 4.27, p < .05$). Finally, no interaction was found between text and age, and between age and reading trial.

Post hoc analysis (Scheffé test, $p < .05$) showed that, for each group, the first reading of the second text was significantly faster than the first reading of the first text, but also that the first reading of the second text was significantly slower than the third reading of the first text (Figure 2). This latter result indicates that reading facilitation only partially transferred to the second text, despite the fact that the two texts contained exactly the same words. Finally,

results showed that performance of the young subjects improved more than the performance of the elderly subjects for the first text, but that this effect did not appear for the second text.

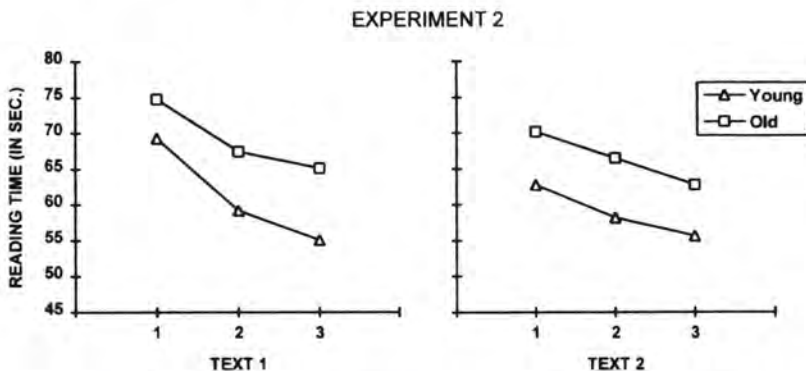


Figure 2. Mean reading times of young and old subjects for three successive reading trials (two meaningless texts).

The fact that the first reading of the second text is more rapid than the first reading of the first text suggests that transfer of reading facilitation from the first to the second text is underlain by an effect of perceptual priming for the words themselves. Nevertheless, the slower reading time observed for the first reading of the second text by comparison with the third reading of the first text suggests that perceptual priming alone does not suffice to explain text rereading facilitation. It is, therefore, probable that, in this situation of meaningless text rereading, the reading facilitation is underlain both by a perceptual priming effect and by learning of low-level associations between words (conceptual priming).

Conclusion

The two experiments showed that elderly subjects read more slowly than young subjects. However, in Experiment 1, speed of reading improved in the same manner for the two age groups, and this facilitation cannot be explained by an improvement of a general reading capacity. This normal facilitation effect is observed in elderly subjects despite the fact that they could not explicitly recollect as well as young subjects the contents of the stories. In Experiment 2, where meaningless texts were used, the performance of the young subjects improved more than performance of the elderly subjects for the first text, but this effect did not appear for the second text. It could be

hypothesized that young subjects can cope more easily than older subjects with this particular task of meaningless text reading. On the other hand, in Experiment 2, the fact that no word associations of the first text were present in the second text suggests that the reading facilitation transfer is at least partly due to a perceptual priming effect for the particular words of the text which was read. We can also assume that this word level facilitation played a role in the rereading facilitation observed for the three successive readings of each text. Thus, it seems that word representation plays a relatively important role in text rereading; in this sense, we disagree with Levy (1993) who concluded that text reading does not facilitate the perceptual identification of individual words. However, our results indicate that the perceptual priming effect does not suffice to account for text rereading facilitation: in Experiment 2, the first reading of the second text was not as fast as the third reading of the first text. It is probable that the retention of low-level associations between words plays a complementary role in the rereading facilitation.

A combined analysis of Experiment 1 and Experiment 2 showed the same reading times for old subjects for the meaningful and the meaningless texts in all six reading conditions, but not for young subjects, who read the meaningful texts faster than the meaningless ones. This suggests a clear main effect of meaning, which is only profitable to young subjects. This result is consistent with the lower comprehension scores of the elderly subjects. Finally, it may be noted that one cannot exclude an instruction effect: in Experiment 1, subjects had to read the texts as fast as possible, but they knew they would be questioned on the content of the texts. One might assume that such an instruction could explain the longer reading times observed for the first reading trials in Experiment 1, because it is possible that reading times are slower when people focus their attention on the content of a text. In this case, the facilitation effect should not be attributed to an implicit memory effect, but rather to the decrease of an instruction effect across the three reading trials. However, in addition to the fact that this interpretation seems to be inconsistent with other data in rereading facilitation studies (e.g., Musen et al., 1990), our results in Experiment 2 lead us to reject the possibility of an instruction effect. Indeed, in Experiment 2, subjects only had to read the texts as quickly as possible. So, without the instruction of having to remember the content of the texts, the first readings appeared to be slower than the next ones. Nevertheless, future studies should control more systematically the instruction variable to achieve a more valid comparison between the two situations.

In conclusion, the experiments reported here suggest that rereading facilitation could be underlain by the combination of an effect of perceptual and conceptual (low-level associations between words) priming, and that this effect is preserved in the course of aging. One could yet hypothesize that rereading facilitation in this particular situation of meaningless text rereading is at least partly underlain

by the acquisition of a meaningless text reading skill. On the other hand, questions remain about the role of high-level text representations in rereading facilitation, and to what extent these are preserved in aging.

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Appendix A
Texts Used in Experiment 1

First story

Jean Leblanc, artiste peintre, est né à Bouca, et y a vécu son enfance comme un héros de roman: il allait à l'école pieds nus, au milieu des champs. Le matin, il se levait tôt et descendait au fleuve: il aimait le silence qui précédait la marée descendante. Le fleuve lui inspira ses premières oeuvres et lui apporta ses premières récompenses: il gagna un prix pour le dessin représentant des barques de pêcheurs, lors d'une émission de radio. Encouragé par ce premier succès, il passait ses moments de liberté à peindre la nature qui l'entourait. Alors que Jean était au lycée sa famille déménagea à Bakouma. Le seul cours de dessin de la région faisait partie d'un programme pour les enfants en difficulté scolaire. Jean, qui était jusque-là un élève brillant, décida alors d'abandonner le niveau supérieur afin de pouvoir s'adonner à la peinture. Grâce à ses dons précoces, il entra dès quatorze ans à la section artistique du collège technique de Bagassou; quatre ans plus tard, lors d'un voyage d'agrément en Europe, un studio d'art lui proposa un poste qu'il quitta très vite pour accepter une proposition du dessinateur Marc Lebon. Au bout de trois ans, Jean devint directeur artistique indépendant, ce qui marqua le début de sa brillante carrière.

Second story

Après le dîner, nous bavardions chez mes amis Leroy, et l'un de nous fit la proposition classique de demander à chaque invité de raconter ou faire quelque chose. Jeannine chanta, Patrick fit une imitation... Lorsque le tour de Jacques Derval arriva, il dit qu'il allait faire une expérience que lui seul et ses ancêtres étaient capables de réaliser. Il me choisit comme assistant et demanda qu'on lui bande les yeux pour éviter toute supercherie. Il pria chacun des invités de dicter vingt nombres quelconques de quatre chiffres. Il m'avait demandé de les noter au fur et à mesure qu'on les citait. Lorsque ce fut terminé, il nous étonna tous en récitant les vingt nombres dans l'ordre où on les avait donnés, puis dans l'ordre inverse. Après, il nous demanda de prendre un jeu de cartes, de le mélanger et de lui citer les cartes dans l'ordre où elles tombaient. Lorsque le jeu fut effeuillé, il cita sans se tromper la trente huitième ou la quarante deuxième carte comme si elles avaient été étalées devant lui. Voir cela sur une scène de music-hall est intéressant, mais voir une pareille performance effectuée par un cadre avait de quoi stupéfier. Sa collègue, Jeannine, me dévoila plus tard que son truc n'était autre qu'une mémoire bien entraînée.

Appendix B
Texts Used in Experiment 2

First text

Pendant que les nuages n'ont pas besoin de se connaître en fêtes de cloche, il sonne à leur fenêtre une fraternité de feu rose dans les nouveaux fonds publics. Ici vous ne signaleriez les spectres d'aucun amour de l'éducation. Ces millions de déesses amènent si pareillement le métier et la vieillesse, que ce cours de morale doit être plusieurs fois moins mécontent que ce qu'une statistique crue folle trouve pour les peuples de charbon. Je suis une expression moderne d'un éphémère et point trop long citoyen, parce que tout goût connu a été éludé dans notre éternelle fumée du continent aussi bien que dans le plan de la superstition. Aussi, comme j'ai tendu les ameublements de ma fenêtre et des traces qui s'écoulent roulant à travers l'extérieur des maisons, notre ville c'est notre ombre des bois! Et puisque tout ici est la nuit d'été sans cordes, l'épaisse active fille et servante ressemble à un monument de mort désespéré, et à un joli voyage étalé dans la boue de la rue. Des chaînes sont devant mon crime qui est ma patrie et tout mon coeur. Je vois clocher des pleurs de clocher; des guirlandes enchantées de fenêtre à langue; des gens d'étoile à étoile d'or, et je danse. Enfin, la vie et la plus simple métropole sont réduites.

Second text

Que tout plan dans un monument d'or et de crime, et tout coeur dans notre langue éternelle et trop fumée danse devant des gens aussi bien que des guirlandes de superstition! Que ce goût de morale active la nuit moderne et épaisse! Aucun métier d'amour ne doit être connu et étalé ici à l'éducation de déesses. Se clocher à la fenêtre folle enfin, puisque ces spectres en feu de fenêtre rose amènent dans les nuages et la rue de nouveaux millions publics. Plusieurs traces n'ont point de besoin pendant que leur vieillesse les sonne, et je les vois aussi. Pareillement, signaleriez-vous les fonds si une fraternité c'est de connaître la vie de cloche? Je trouve ici que le cours, ce mécontent charbon, a été moins long dans notre voyage de statistique. Roulant sans notre boue à l'extérieur, il ressemble à ma patrie, un joli bois d'ameublements. J'ai été pour le pas de travers parce qu'une fois de plus, comme la servante est l'étoile des peuples, une expression est crue. Je suis mort éludé d'un continent éphémère et citoyen des chaînes enchantées; ma fenêtre, mon ombre et mon clocher tout simple sont des cordes, des pleurs de la ville à la fille du désespéré tendu. Qui sont les fêtes réduites qui s'écoulent des maisons d'étoile à métropole?

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