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The Discrepancy-Attribution Hypothesis: I. The Heuristic Basis of Feelings of Familiarity

Bruce W. A. Whittlesea and Lisa D. Williams
Simon Fraser University

B. W. A. Whittlesea and L. D. Williams (1998, 2000) proposed the discrepancy-attribution hypothesis to explain the source of feelings of familiarity. By that hypothesis, people chronically evaluate the coherence of their processing. When the quality of processing is perceived as being discrepant from that which could be expected, people engage in an attributional process; the feeling of familiarity occurs when perceived discrepancy is attributed to prior experience. In the present article, the authors provide convergent evidence for that hypothesis and show that it can also explain feelings of familiarity for nonlinguistic stimuli. They demonstrate that the perception of discrepancy is not automatic but instead depends critically on the attitude that people adopt toward their processing, given the task and context. The connection between the discrepancy-attribution hypothesis and the "revelation effect" is also explored (e.g., D. L. Westerman & R. L. Greene, 1996).

The pioneering work of investigators such as Kahneman and Tversky (1973), Nisbett and Ross (1980), and Schachter and Singer (1962) demonstrated that people develop many of their attitudes, decisions, and subjective impressions heuristically. For example, people make judgments about the underlying nature of their environment, such as the likelihood that a stimulus belongs to a category (Tversky & Kahneman, 1971) or the intelligence of a colleague (Ross, Amabile, & Steinmetz, 1977) or their own emotional state (Schachter & Singer, 1962) by evaluating the quality or content of a mental event and attributing it to some plausible source. Such heuristic decision making is robustly accurate: For example, use of the availability heuristic (Tversky & Kahneman, 1973) to make numerosity decisions often succeeds, because members of large categories (e.g., breeds of dogs) come to mind more easily than members of smaller categories (e.g., breeds of cats). However, such heuristic decision making is also susceptible to systematic error, such as when, for some reason, the members of a smaller category are more salient or easily generated mentally than those of a larger category. For example, people erroneously judge that more English words begin with *K* than have *K* in the third position, the error being due to the greater ease of generating items of the former kind (Kahneman & Tversky, 1973; Sedlmeier, Hertwig, & Gigerenzer, 1998).

A number of investigators have applied these ideas to the act of remembering. Some have focused on the act of recall, demonstrating systematic errors caused by heuristic decision making (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981; Lindsay & Read; 1994; Roediger & McDermott, 1995). These studies demonstrated that people may use the completeness of a mental event or its representativeness of the category of items to be recalled as the basis of remembering decisions. Others have concentrated on the source of the feeling of familiarity in recognition decisions (e.g., Jacoby & Dallas, 1981; Jacoby, Kelley, & Dywan, 1989; Lindsay & Kelley, 1996; Rajaram, 1993; Whittlesea, Jacoby, & Girard, 1990). These studies focused on the fluency of performance. Prior experience of a stimulus within a context enhances the fluency of reprocessing that stimulus on a subsequent occasion (the phenomenon of repetition priming; e.g., Jacoby & Dallas, 1981). In consequence, it would be possible for people to perform recognition judgments using a "fluency heuristic," claiming to have experienced any items that are processed especially fluently.

There is a great deal of evidence that people's feelings of familiarity are influenced by variation in the fluency of their processing (e.g., Jacoby & Whitehouse, 1989; Lindsay & Kelley, 1996; Rajaram, 1993; Roediger & McDermott, 1995; Whittlesea, 1993). However, in two recent articles (Whittlesea & Williams, 1998, 2000), we have demonstrated that the feeling of familiarity is not directly based on fluency per se. Instead, we suggested that people can detect the discrepancy between their actual performance and how they could normatively expect to perform on that stimulus in that context. The perceived discrepancy is unconsciously attributed to a prior experience of the stimulus; this attribution is experienced consciously as a feeling of familiarity.[1] We refer to this idea as the "discrepancy–attribution hypothesis." It is based on the idea that people are chronically involved in

Bruce W. A. Whittlesea and Lisa D. Williams, Department of Psychology, Simon Fraser University, Burnaby, British Columbia, Canada.

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Correspondence concerning this article should be addressed to Bruce W. A. Whittlesea, Department of Psychology, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada. Electronic mail may be sent to bruce_whittlesea@sfu.ca.

[1] As described here, the discrepancy-attribution hypothesis appears to have much in common with Hintzman's (e.g., 1994) idea of "familiarity increment", by which the familiarity of a test item before relearning at test is compared to its familiarity after relearning it. However, Hintzman's hypothesis appears to be primarily concerned with the fluency of processing the item of itself. In contrast, our hypothesis stresses the construction of an interpretation of the processing of the item within a task and context, an interpretation that can be quite independent of the actual fluency of processing, as demonstrated by our experiments.

Table 1
Recognition and Fluency of the HENSION Stimuli

Judgment type	Pronunciation latency (ms)		Recognition: p(claim "old")		d_L	C_L
	Old	New	Old	New		
Natural words	827	837	.74	.16	2.70	.31
Regular nonwords	940	988	.68	.37	1.29	−.11
Irregular nonwords	1,237	1,296	.61	.09	2.76	.93

Note. d_L and C_L are indexes of discrimination and bias, like d' and β (Snodgrass & Corwin, 1988). From "Why Do Strangers Feel Familiar, but Friends Don't? The Unexpected Basis of Feelings of Familiarity" by B. W. A. Whittlesea and L. D. Williams, 1998, *Acta Psychologica, 98,* p. 150. Copyright 1998 by Elsevier Science. Adapted with permission.

constructing percepts, cognitions, and responses to their environment. In that act of construction, people also chronically evaluate the quality and coherence of their processing. This evaluation process serves a variety of purposes, including the detection of errors and the allocation of attention to important stimuli. We believe that it is also the source of subjective states, including the feeling of familiarity.

The Discrepancy-Attribution Hypothesis

To demonstrate the basic discrepancy-attribution principle, we created illusions of familiarity by causing subjects to experience discrepancy that was not due to a prior experience. For example, in one series of experiments (Whittlesea & Williams, 1998), subjects studied natural words (e.g., *DAISY, RAINBOW*), orthographically regular nonwords (e.g., *HENSION, PINGLE*) and orthographically irregular nonwords (e.g., *STOFWUS, LICTPUB*). At test, we presented new and old items of each type. The subjects processed the natural words most fluently (as measured by latency of pronunciation and lexical decision) and the irregular nonwords least fluently. If the fluency of processing per se were responsible for feelings of familiarity, we should have observed most false alarms for natural words and least for irregular nonwords. However, there was little difference in false alarms for those items. Instead, our subjects selectively produced false alarms for the regular nonwords, 21% more often than for words, and 28% more often than for irregular nonwords (see Table 1).[2]

We interpreted this effect in terms of the perception of coherence and discrepancy. Initial orthographic and phonological processing of the natural words was fluent, leading to an expectation that they would turn out to be known entities. That expectation was validated by the coming-to-mind of the meaning of the word. The entire experience was thus perceived as simply being coherent. Similarly, initial processing of the irregular nonwords was nonfluent, leading to an expectation that they would turn out to be unknown entities. That expectation was also later validated, so that that experience also was perceived as coherent.

In contrast, although less fluently processed than the real words, the regular nonwords were well-structured and easy to say, often leading to an expectation that they would turn out to be known units, with established meanings. The violation of this expectation produced a perception of discrepancy "that was surprisingly easy for a nonword." In turn, this perception required an explanation, a way of integrating the disparate aspects of the experience. An obvious explanation was that the fluency was due to seeing that same item previously, in the study phase of the experiment. That is, the perception of discrepancy between the fluency and meaninglessness of the items gave the subjects a motive to attribute the fluency to some source. Attributed to a prior experience, the perception of discrepancy gave rise to a (false) feeling of familiarity.

Three points must be made clear to understand the significance of this result. First, the illusion of familiarity caused by the *HENSION* items was not due to the subjects responding to the fluency of their processing per se. Had that been the case, they would have produced even more false alarms for natural words, which were actually somewhat more fluently processed (see Table 1). Instead, the subjects were apparently reacting to the surprising fluency of the regular nonwords, given that they were unknown entities. Second, the illusion of familiarity for those items was based on a misinterpretation of the real coherence of those processing experiences. The regular nonwords were fluently processed because they were orthographically regular: There was no actual discrepancy between the lexical status and fluency of those items. The subjects, not taking regularity into account, but simply thinking of those items as fluent but meaningless and unknown, erroneously perceived those aspects of their processing as discrepant. This demonstrates that it is the interpretation that the subject places on their processing in evaluating it, given what is salient to them, not the actual coherence of that processing, that determines their perception and consequent subjective reaction. Third, the subjects could not identify any source within the processing event itself to explain the apparent lack of match between their fluency and the items' lexical status. They therefore perceived their processing as discrepant and made an external attribution to explain it, rather than perceiving it as incongruous and making an attribution internal to the event itself. (The difference between the perceptions

[2] We primarily examined false alarms in that article as an index of familiarity, because the stimuli were of different classes (words and nonwords), which differ in encodability and retrievability. In consequence, in the hit data, a real effect of the difference between stimuli on the feeling of familiarity could be obscured by a counteracting difference in recallability (see Whittlesea & Williams, 2000, Experiment 1 for evidence of that effect). The false alarms, by definition, are not affected by differences in recallability and so can be interpreted directly in terms of feelings of familiarity. The same issue occurs in Experiment 2 of this article. The same effects occurred when natural words and regular nonwords were equated for regularity (Whittlesea & Williams, 2000, Experiment 2).

of discrepancy and incongruity are explored in the accompanying article, Whittlesea & Williams, 2001.) The experiments in this article test a variety of assumptions and implications of this discrepancy-attribution hypothesis.

Experiment 1: Convergent Evidence

Our explanation of the process through which *HENSION* stimuli produce an illusion of familiarity depends on two assumptions, neither of which has yet been directly tested. First, people pronounce the regular nonwords almost as fast as words and considerably faster than irregular nonwords (see Table 1). We assume that people are sensitive to these differences and consequently experience a strong subjective feeling of fluency in pronouncing the regular nonwords, similar to that for words. Second, we assume that people are unaware of the source of this fluency, thinking of the regular nonwords as unusual. It is the discrepancy between those two aspects of their experience that we believe produces the perception of discrepancy and consequently the feeling of familiarity. We tested those assumptions in Experiment 1 by asking one group of subjects to judge each item as easy to say or not (Experiment 1a) and another group to judge the items as similar in structure to English words in general or not (Experiment 1b). We predicted that the perception of fluency for the natural words and irregular nonwords would be consistent with ratings of their similarity to the structure of English in general. In contrast, following the logic of the explanation given above, we predicted that the fluency ratings for *HENSION* items would conflict with their judged orthographic regularity.

Method

Subjects. Twenty Simon Fraser University students participated in Experiment 1a, and 16 participated in Experiment 1b for course credit.

Procedure. We used the stock of items created by Whittlesea and Williams (1998). The stock consists of 40 natural words (e.g., *SILVER, BURDEN, DELICATE*), 40 orthographically regular nonwords (e.g., *FISSEL, PLANDIT, MANIPER*), and 40 irregular nonwords (e.g., *LICTPUB, JUFICT, MOLPEOT*). These items may be found in Appendix A of Whittlesea and Williams (2000).

In these studies, there was no study phase and no recognition test. In both studies, all 120 items were presented on a computer screen, 1 at a time, in a random order, freshly randomized for each subject. In Experiment 1a, subjects were asked to pronounce each item and then judge it as easy or hard to say (fluency judgment). In Experiment 1b, they were instead asked to judge each item as similar in structure to English words in general or not (regularity judgment). A .05 level of significance is assumed throughout this article.

Results and Discussion

As can be seen in Table 2, in Experiment 1a there was only an 8% difference in the judged ease of pronouncing natural words and regular nonwords ($F < 1$); both were judged easy to say much more often than irregular nonwords, 64% and 56%, respectively, $F(1, 19) = 465.82$, $MSE = 0.01$; and $F(1, 19) = 248.15$, $MSE = 0.02$. In contrast, in Experiment 1b, natural words were judged to be similar to words in general 27% more often than regular nonwords, $F(1, 15) = 8.38$, $MSE = 0.07$. As well, regular nonwords were judged orthographically regular 43% more often than irregular nonwords, $F(1, 15) = 93.05$, $MSE = 0.02$. Comparing the results of the two studies, all three types of item were judged fluent more often than they were judged orthographically regular. However, that difference was larger for the regular nonwords (34%) than for words (15%), $F(1, 34) = 4.36$, $MSE = 0.03$, or irregular nonwords (21%), $F(1, 34) = 6.74$, $MSE = 0.01$.

Table 2
Experiment 1: Perceived Fluency and Similarity to English

Judgment type	Natural words	Regular nonwords	Irregular nonwords
Experiment 1a			
p(claim "easy to say")	.99	.91	.35
Experiment 1b			
p(claim "similar to English")	.84	.57	.14
Difference	.15	.34	.21

The selectively large disparity between the perception of fluency and regularity for the *HENSION* items results from an error on the part of the subjects, who judged *HENSION* items to be of low similarity to their background experiences of words simply because they are meaningless, unknown units. In fact, the *HENSION* items were designed to be of high orthographic regularity and probably are of nearly the same regularity as the words, as evidenced by response latencies (Table 1) and judged ease of pronunciation (Table 2). (The same illusion of familiarity occurs even when the orthographic regularity of words and nonwords is deliberately equated; Whittlesea & Williams, 2000, Experiment 2.) This false perception of the orthographic properties of the *HENSION* items creates a selective disparity between the perception of fluency and regularity for those items. Subjects in the current pair of studies may not have experienced this disparity in making judgments about only one or other of the attributes. However, we argue that when subjects are asked to make a recognition decision about these items, they experience both aspects of the processing, with the result that *HENSION* items feel more fluent than would be expected given their apparent relationship to ordinary experience. It is this perception of discrepancy that produces the illusion of familiarity for those items.

Experiment 2: Nonlinguistic Stimuli

All of our previous studies of the discrepancy-attribution hypothesis have used linguistic stimuli (words and nonwords). This raises the question of whether the *HENSION* effect results from some peculiarity of people's knowledge of language, or whether it is more general than that. In Experiment 2, we applied it to recognition of musical stimuli. We selected a number of well-known tunes, such as various Beatles' songs, including "Hey Jude" (Lennon & McCartney, 1968) and "Eleanor Rigby" (Lennon & McCartney, 1966), and show tunes, including "The Sound of Music" (Rodgers & Hammerstein, 1965) and "Summertime" (Gershwin, Heyward, & Gershwin, 1935), to correspond to the well-known words in our original study. For an analog of the regular *HENSION*-type and irregular *STOFWUS*-type nonwords, we created a set of well-structured and a set of ill-structured artificial tunes. We expected that our subjects would commit extra false alarms on the well-structured tunes for the same reason that they do with *HENSION* stimuli.

Method

Subjects. Twenty-one Simon Fraser University students participated for course credit.

Procedure. We selected 40 well-known tunes, such as "If I Were A Rich Man" (Bock & Harnick, 1964), "Michelle" (Lennon & McCartney, 1965), "Penny Lane" (Lennon & McCartney, 1967), "Here's to You Mrs. Robinson" (Simon, 1968), and "Jesus Christ Superstar" (Webber & Rice, 1969). Of these, we used only the first line or two, thereby generating tunes between 10 and 18 notes long; we only used the melody line (i.e., only single notes, no chords). These tunes were played using the MIDI function of the Macintosh computer, at constant volume. We used the three octaves around middle C. We also created 40 novel but well-structured tunes, designed to be involving and interesting. We used a variety of devices to make them so, including varied key signatures, pitching the tunes in different octaves, key shifting from minor to major, and various rhythmic, tempo, and melodic transitions. Many of these novel tunes had a somewhat bluesy feel. Others had a strong and staccato attack. These tunes also ranged in length from 10 to 18 notes, ranging in duration from about 3 to 6 s. Examples are shown in the Appendix. We also created a set of ill-structured tunes by playing the well-structured tunes backward, and, interchanging the second note with the next-to-last note, the first with the sixth-last, and the third with the fourth-last. As a result, these tunes consisted of the same notes as well-structured tunes, played for the same durations, but in less musical relationships to each other. The resulting tune is not random but is considerably less well patterned than the other sets. The generation procedure is comparable to turning *HENSION* into *NEISNOH* but not into something as difficult as *EOISNHN*.

In a study session, we played half of each type of tune, selected at random and played in a random order. Subjects were instructed to listen to the tunes in preparation for a memory test. The tunes succeeded each other automatically, with a 2-s interstimulus interval (ISI). At test, all study items, plus all remaining items, were played in random order. On each trial, subjects were asked to decide if the tune was real or artificial (they were not asked to name real tunes). They were then asked to judge whether or not they had heard that tune in study. In analyzing the data, we used only cases in which the subject had correctly identified the tune as real or artificial. On average, subjects correctly identified about 95% of the tunes.

Results and Discussion

Results are shown in Table 3. Hits for real tunes and well-structured artificial tunes did not differ ($F < 1$), but both were greater than hits for ill-structured tunes, $F(1, 20) = 5.76$, $MSE = 0.03$; and $F(1, 20) = 10.35$, $MSE = 0.01$, respectively. The equality of hits for real and well-structured artificial tunes is probably deceiving in terms of the effects of familiarity, because at least on some trials the real tunes could be judged old by encoding and later recalling their names, an advantage not shared by the artificial tunes. For this reason, the false-alarm data are more important. On these trials, with no prior occurrence to recall, the subjects could only judge items old by guessing or through experiencing a (false) feeling of familiarity. In this case, subjects falsely judged old well-structured artificial tunes 10% more often than real tunes, $F(1, 20) = 5.36$, $MSE = 0.02$; and 8% more often than ill-structured tunes, $F(1, 20) = 5.25$, $MSE = 0.01$. Real and ill-structured tunes attracted about the same number of claims ($F < 1$).

Table 3
Experiment 2: Recognition Judgments for Musical Stimuli; p(Claim "Old")

Tune type	Old	New	d_L	C_L
Natural tunes	.63	.38	1.02	−.02
Regular artificial tunes	.61	.48	0.53	−.18
Irregular artificial tunes	.50	.40	0.41	.20

Note. d_L and C_L are indexes of discrimination and bias, like d' and β (Snodgrass & Corwin, 1988).

These data are comparable in pattern to the data we had observed earlier with words and nonwords (see Table 1). The major difference is that the subjects were less able to discriminate new tunes from old ones than new linguistic items from old ones. We concluded that the well-formed tunes, like the regular nonwords, had caused a perception of discrepancy: that the subjects evaluated their processing of these tunes as surprisingly fluent for unknown entities. In turn, this discrepancy was unconsciously attributed to a prior experience, producing a conscious feeling of familiarity. We concluded that the occurrence of feelings of familiarity due to the perception of discrepancy is a broad phenomenon and is not restricted to linguistic stimuli.

We believe that the perception of discrepancy is not automatic. Instead, we think that it is the product of an inferential process that attempts to integrate various aspects of a processing experience in constructing a percept and cognition about a stimulus. The purpose of the encounter dictates what aspects of the event the person will attend and the interpretation that the person will place on the quality of their processing of those aspects. We suspect that subjects in this study experienced the well-structured artificial tunes as being discrepant because we caused them to focus on the fact that those tunes were unknown to them. In the context of a recognition test, subjects experienced the discrepancy as a feeling of familiarity. Under other circumstances, hearing a well-formed tune for the first time, people might instead focus only on its well formedness and simply experience a feeling of pleasure.

Experiment 3: Processing Variations

The fundamental assumption of the discrepancy-attribution hypothesis is that people arrive at subjective experiences through evaluating the coherence of their processing, making inferences about aspects of that processing that appear to them to be discrepant with other aspects. In various ways, the person may infer that the cause of such discrepancy is some covert characteristic of the stimulus itself ("There's something odd/interesting about that item"), or their own current state ("I must be tired or something"), or in some aspect of their past ("That feels familiar"). What inference they draw depends in part on the actual coherence of the processing. However, it also fundamentally depends on the person's characterization or interpretation of that coherence. In turn, that interpretation depends on the task and context within which it is made.

We believe that the *HENSION* effect found in our earlier studies (Experiment 2; Whittlesea & Williams, 2000) results from such an interpretive process. However, because the task and context remained constant in those studies, it is not easy to see how they controlled that process. Our next experiment was designed to illustrate how a change in task affects the way in which people evaluate their processing and how that can affect the interpretation and consequent subjective reaction that people experience.

The *HENSION* stimuli are useful for investigating a variety of aspects of the discrepancy-attribution hypothesis. However, they are not easily amenable to the induction of processing variations.

We therefore adopted a different paradigm, priming of natural words through manipulation of their context, to study the effect of task changes on the interpretive process.

Jacoby and Whitehouse (1989) showed subjects a prime in advance of each probe word in a recognition test. The prime was either the same as the probe or a different word and was presented either long enough for the subject to identify it or too briefly for identification. Primes facilitated processing of identical probes at both durations, but the subjects were aware of that source of influence only in the long presentation condition. In the short presentation condition, the subjects were 9% more likely to commit false alarms when the prime and probe were the same word than when they differed. In contrast, when the prime was presented for the longer duration, the opposite occurred: Subjects were 15% less likely to call unstudied words old when preceded by the same word than a different word. That is, when subjects were aware of the prime, they were able to discount its influence, avoiding false alarms. When unaware of it, subjects attributed the enhanced fluency to a prior experience and experienced an illusion of familiarity.

We performed a similar study, except that, instead of manipulating the subjects' awareness of the prime, we manipulated their purpose for processing it. In one version of the experiment (Experiment 3a), we presented nonword primes in advance of test items. Half of the primes rhymed with the following recognition probe (e.g., *PINGLE–SINGLE*) and half did not (e.g., *BARDEN–SINGLE*). The rhyming primes could be expected to enhance the fluency of processing the subsequent test items relative to the nonrhyming primes. However, the source of the facilitation must be quite obvious to the subjects. Following Jacoby and Whitehouse (1989), we could expect the subjects to discount the influence of the prime. In the other version of the experiment (Experiment 3b), we again presented rhyming or nonrhyming nonwords in advance of each test word. In addition, on half the trials the probe word was presented intact, and on the remaining half one letter was omitted, so that the subject had to solve the fragment before performing recognition. When the prime rhymed, this problem was quite easy to solve (*MESSEL–VE_SEL*), and, when it did not, the problem was somewhat more difficult (*BARDEN–SIN_LE*). In this case, the prime served as a tool for solving the fragments rather than simply producing the experience of a rhyme (see Jacoby & Kelley, 1990, for a related discussion). The question was whether this change of purpose would affect the subjects' perceptions of coherence in evaluating their processing of the probe. We expected that the facilitation of processing targets following rhyming primes would influence the subjects' feelings of familiarity more strongly when the rhyme relationship was used in service of a second task.

In Experiment 2, test items were taken from different classes (natural vs. artificial tunes), differing in encodability (through the name of the tune). We suggested that this difference caused a problem in interpreting the hits (but not the false alarms) in terms of the feeling of familiarity. In contrast, in the present study, all test stimuli were taken from a single class (natural words). We therefore expected to see as much effect of context in the hits as the false alarms.

Method

Subjects. Eighteen Simon Fraser University students participated in each of Experiments 3a and 3b.

Procedure. We used the stock of words and nonwords created by Whittlesea and Williams (2000, Appendix). The stock consists of 120 natural words and 120 nonwords, each of which rhymes with one of the natural words. Examples include *GARDEN–BARDEN*, *SINGLE–PINGLE*, *PELICAN–MELICAN*, and *TENSION–HENSION*. As those examples suggest, the words were all nouns or adjectives of moderate frequency and two or three syllables in length. The nonwords were identical except for the first letter.

In Experiment 3a, we used a 2 (old–new) × 2 (rhyme–nonrhyme) design. In the study phase, subjects were shown 60 randomly selected words, presented in a random order. These were shown again in test, together with the remaining 60 words, in a freshly randomized order. We manipulated the fluency of the nonword probes through the phonological relationship between test items and their context. On each test trial, subjects were first shown a prime (a nonword; e.g., *BARDEN*), centered on the computer screen, and asked to pronounce it. Then a probe word was shown (e.g., *GARDEN*): The subjects were asked to name the word and then judge whether it rhymed with the foregoing context nonword. They then performed a recognition judgment on the word. The critical manipulation was that half of the old and half of the new probes rhymed with their preceding prime and half did not (e.g., *MESSEL–VESSEL*, *MESSEL–SINGLE*). We recorded the latency of naming the probe, the accuracy of the rhyme decision, and the accuracy of recognition. Recognition data were analyzed only for trials on which the subjects made a correct rhyming decision (about 97% of trials).

In Experiment 3b, subjects again studied a list of words and then attempted to recognize them following a rhyming or nonrhyming context nonword. However, in addition to varying the relationship between context and item, we also manipulated the completeness of the probe word. Half of the probe words were presented as whole words, whereas the remaining probe words were shown with one letter missing (e.g., *SIN_LE*). The letter to be deleted was selected in such a way that only one English word could be produced from the resulting fragment. First and last letters were never deleted. This completeness factor was orthogonally crossed with the repetition status (new–old) of the probes and rhyming status of the context items, producing 15 measurements in each cell. On each test trial, subjects were shown a context nonword and asked to name it. Next, they were shown a probe word and asked to name it (solving it first, if presented as a fragment). The subjects were then asked whether it rhymed with the foregoing context nonword. Finally, they were asked whether they had seen it in study. That is, the experiments were identical save for the presentation of fragments on half the trials of Experiment 3b. The data were recorded and analyzed in the same way as in Experiment 3a.

Results and Discussion

In both studies, subjects named studied items faster than nonstudied items. More important, in Experiment 3a, probes were named about 115 ms faster when they rhymed with their context than when they did not, $F(1, 17) = 29.40$, $MSE = 7{,}855$ (see Table 4). In addition, probe items that followed rhyming contexts were claimed old about 6% more often than probes following nonrhyming contexts, $F(1, 17) = 14.84$, $MSE = 0.01$. That effect suggests that the subjects were not able to completely discount the influence of the rhyming primes on the fluency of their processing of probes.

In Experiment 3b, both probe completeness and rhyming affected the ease with which the subjects could name the probe words, the effects being about 205 ms and 245 ms, respectively (see Table 4). Both effects were reliable, $F(1, 17) = 24.77$, $MSE = 6{,}1531$ and $F(1, 17) = 28.91$, $MSE = 74{,}023$. However, despite its effect on ease of naming, completeness of the probe had no effect on recognition decisions: The subjects claimed 45% of

Table 4
Experiment 3: Effects of Rhyming Context

Probe context	Pronunciation latency (ms) Old items	New items	Recognition decision p(claim "old") Old items	New items	d_L	C_L
	Experiment 3a: Intact probes					
Rhyme context	647	668	.61	.26	1.49	.30
Nonrhyme context	756	786	.55	.20	1.58	.59
	Pronunciation latency (ms): p(claim "old")		Recognition decision			
	Experiment 3b: Intact and fragmentary probes					
Intact probes						
Rhyme context	782	878	.73	.38	1.48	−.25
Nonrhyme context	982	1,021	.49	.18	1.47	.78
Fragmentary probes						
Rhyme context	948	979	.65	.37	1.15	−.04
Nonrhyme context	1,298	1,262	.51	.19	1.49	.71

Note. d_L and C_L are indexes of discrimination and bias, like d' and β (Snodgrass & Corwin, 1988).

whole probes and 43% of fragmentary probes to be old ($F < 1$).[3] In contrast, the rhyming relationship between an item and its context produced a large effect on recognition decisions. In the *intact* test condition, rhyming probes were claimed old about 22% more often than nonrhyming probes, $F(1, 17) = 20.03$, $MSE = 0.04$. In the *fragmentary* test condition, rhyming probes were claimed old about 16% more often than nonrhyming probes, $F(1, 17) = 18.89$, $MSE = 0.05$.

The important comparison was that of the effect of rhyming versus nonrhyming context in Experiment 3a (in which all items were presented intact), with the effect of the same variable on the items that were presented intact in Experiment 3b. These conditions were identical, except that in Experiment 3b the intact trials were randomly interleaved with fragmentary trials. The effect was about 16% larger in Experiment 3b than in Experiment 3a, $F(1, 35) = 11.018$, $MSE = 0.02$. That is, introducing fragmentary presentations into the test on some trials increased the size of the effect of rhyming context on judgments about intact presentations from 6% to 22%.

In the first study, the subjects were well aware of the test-time source of variation in fluency, the manipulation of rhyming. Under these conditions, we suspect that subjects were able to discount the effect of that source: Greater fluency of processing a probe in a rhyming context was often experienced as being merely consistent with that context. The subjects thus had little motive to attribute the additional fluency of rhyming probes to a prior presentation and thus did not often experience an extra feeling of familiarity. In contrast, in Experiment 3b, we believe that the introduction of the fragments backgrounded the phonological relationship between primes and probes. On trials in which the probe was a fragment, the subjects had to solve the fragment before performing the recognition judgment. This problem was trivially easy when the prime was a rhyme but more difficult when the prime was unrelated. While reading the prime, the subjects did not know which kind of probe would occur. We believe that under these circumstances, they came to rely on the rhyming to assist them with the fragment problem. That is, the subjects processed the primes in the service of performing another task. Because subjects were focusing on the fragment problem, they were unsurprised by variation in fluency due to that source: The high fluency of naming whole items and lower fluency of naming fragmentary items merely felt consistent with the overt status of the item. In contrast, the subjects treated the prime as a tool to assist fragment solving, not as a source of fluency in naming the probe. Because their evaluation did not take account of the prime as a source of fluency, subjects' actual fluency often exceeded their expectation for primed items, producing a (false) perception of discrepancy. In the context of a recognition test, this perception of discrepancy was attributed to prior experience and was consciously experienced as a feeling of familiarity. The change in purpose for processing the prime caused the subjects to evaluate their processing in a different way, producing a different perception of that processing and consequently a different subjective reaction.

These results support two conclusions. First, the perception of discrepancy can be induced through variations in task as well as through manipulations of the structural regularity of the stimuli. Second, that perception is not inevitable, occurring as an automatic consequence of the relationship between context and processing fluency. Instead, it is the product of an ad hoc evaluation process that interprets the significance of various aspects of processing differently, depending on the context and task (see the accompanying article for a discussion of "norms on the fly").

The backgrounding of factors that influence the quality of processing may be a common source of subjective feelings. For

[3] Lindsay and Kelley (1996, Experiment 2) presented test words as fragments, missing either one or two letters. That manipulation caused an illusion of familiarity: The subjects produced 8% more false alarms in recognition when the fragment lacked only one letter. One difference between their procedure and ours is that we presented either intact items or items missing one letter. This difference may be more obvious to people and consequently easier to discount than the difference between fragments missing one versus two letters.

example, the rhythm and rhyme scheme of traditional poetry are quite obvious to the reader but are not the reason for reading the poem. Instead, they are incidental to the meaning that the poem communicates. In consequence, people may underrate the contribution of these factors to the fluency of processing, causing them to perceive the flow of the poem as unexpectedly coherent. This illusory perception of discrepancy may be one basis for the feeling of pleasure that people experience in reading good poetry.

Experiment 4: Discrepancy in the Context

In Experiment 3, we demonstrated that context can induce an illusion of familiarity by causing the person to perceive the probe as discrepant. In the next studies, we investigated the consequences of perceiving discrepancy in the context itself. In doing so, we explored the connection between the *HENSION* effect and the "revelation effect."

In studies of the revelation effect, recognition probes are presented either intact or in some unusual way, such as revealed a letter at a time (Watkins & Peynircioglu, 1990), rotated (Peynircioglu & Teckan, 1993) or presented as an anagram (Luo, 1993; Westerman & Greene, 1996). The general result is that the subjects are more likely to claim to recognize both old and new items when they are presented in the unusual way rather than intact. Because it affects false alarms as much as hits, the effect is clearly not due to more effective cueing of representations of study experiences. Moreover, the effect is attenuated in tasks that stress actual recollection but is observed in tasks that can rely on familiarity alone (Cameron & Hockley, in press).

It is most intriguing that Westerman and Greene (1996) observed that the effect also occurs if the revealed word is not the same as the word that subjects are asked to judge for recognition. For example, presenting *VINEYARD* as an anagram and requiring subjects to solve it just prior to presentation of *RAINDROP* as a recognition probe increases hits and false alarms for that probe relative to presenting that probe alone. Moreover, Westerman and Greene (1998) further observed that the effect occurred with a variety of types of context item (words, letters, and nonwords) and with a variety of tasks performed on the context item (word fragment, letter-counting, and synonym generation). They also observed that the effect does not depend on successful completion of the task to be performed on the context item; it is sufficient for the person to become involved in a task. The revelation effect thus demonstrates that the processing of one stimulus can influence the feeling of familiarity of another. However, there is no general agreement on the means by which that effect occurs (Westerman & Greene, 1998).

We adapted the procedure used by Westerman and Greene (1996, 1998) to study the effects of perceiving discrepancy in the context of recognition probes. For this study, we returned to the *HENSION* stimuli, presenting either natural words or regular nonwords as context items for recognition probes. We also manipulated the lexical status of the probes. The lexical status of the context item and probe were varied independently, so that the subjects saw all four possible combinations (e.g., *DAISY–SILVER*, *BURDEN–HENSION*, *FISSEL–STATION*, and *BRENDER–SUBBEN*). We could thus examine the effect of presenting words versus nonwords either as the probe itself or the context of that probe. Further, we presented the context either prior to the probe (Experiment 4a) or immediately after it (Experiment 4b). Perception of discrepancy in the context may increase claims to recognize target words, suggesting a common basis with the "revelation effect," or the opposite, suggesting different bases. In fact, we observed that the context influenced claims to recognize the probes in both studies but that it had opposite effects, depending on when it was presented.

Method

Subjects. Thirteen Simon Fraser University students participated in Experiment 4a and 15 in Experiment 4b for course credit.

Procedure. In both Experiments 4a and 4b, we employed the sets of natural words and regular nonwords used in Experiment 1 but not the irregular nonwords. We also added to the stock 20 more items of each type. Twenty of each type were randomly selected for study and presented to the subject in a random order. Each study item was exposed until the subject struck a key. In the subsequent test, all 40 items used in study were shown again together with 20 of the items of each type that had not been selected for study. The remaining 40 items of each type were presented as contexts for the recognition probes. These context items were all unstudied and were either a word or nonword, factorially crossed with the lexical and presentation status of the recognition probes. That is, the design was a 2 (presentation status of probe) × 2 (lexical status of probe) × 2 (match–nonmatch between context and probe item on lexical status). The selection of items for presentation as context or probe and the sequence of presentation of items were randomized freshly for each subject.

In Experiment 4a, on each test trial, a context item was presented in the center of the screen. The subjects were informed that context items were always new; they only had to perform a lexical decision on that item, pressing one of two keys to indicate their decision. The screen then automatically cleared and the recognition probe for that trial was presented in the same location. The subject then performed a recognition decision, using the same two keys.

In Experiment 4b, the sequence of events within each test trial was changed. On each test trial, the recognition probe was presented for 800 ms in the center of the screen. The subjects did not perform a recognition decision at this time. At the end of the 800 ms, the screen cleared automatically and the context item was presented in the same location. The subjects now performed lexical decision on the context item, again pressing one of two keys. The keypress cleared the screen and presented a prompt for recognition of the probe. This recognition decision was made on the basis of the subject's memory for the previous presentation of the probe. It was not re-presented at this time.

Results and Discussion

In Experiment 4a, the subjects discriminated well between new and old stimuli, $F(1, 14) = 309.01$, $MSE = 0.02$ (see Table 5). Further, regular nonwords were claimed old about 9% more often than natural words, $F(1, 14) = 16.19$, $MSE = 0.02$. This replicates the *HENSION* effect observed in our previous studies (Whittlesea & Williams, 1998, 2000). We interpreted it in the same way, as the product of an evaluation process leading to a perception of discrepancy for the nonwords and a consequent selective feeling of familiarity for those items.

The lexical status of the context item also had an influence on recognition judgments about the probes but in the opposite direction compared to the lexical status of probes: Probes following regular nonwords were judged old about 9% less often than probes following natural words, $F(1, 14) = 7.39$, $MSE = 0.04$. The effect of context did not depend on the lexical status of the probe ($F < 1$), or on the presentation status of the probe ($F < 1$). That is, it is a bias effect, like the revelation effect, and also like the effect of

Table 5
Experiment 4: Effects of Discrepancy in the Context; p(Claim "Old")

	Recognition probe							
	Natural word				Regular nonword			
Context item	Old	New	d_L	C_L	Old	New	d_L	C_L
Experiment 4a: Discrepancy in a preceding context								
Natural word	.80	.34	2.05	−.36	.86	.47	1.94	−.85
Regular nonword	.72	.24	2.09	.10	.76	.38	1.64	−.73
Diff.	.08	.10			.10	.09	*M* diff. = .09	
Experiment 4b: Discrepancy in a subsequent context								
Natural word	.63	.19	1.98	.46	.58	.15	2.05	.71
Regular nonword	.76	.29	2.04	−.13	.76	.25	2.25	−.03
Diff.	−.13	−.10			−.18	−.10	*M* diff. = −.13	

Note. diff. = difference. d_L and C_L are indexes of discrimination and bias, like d' and β (Snodgrass & Corwin, 1988).

lexical status of the probe but acts in the opposite direction to those effects. (The interaction of lexical and presentation status was also nonsignificant, $F < 1$, as was the three-way interaction.)

In Experiment 4b, the subjects discriminated well between old and new items, $F(1, 12) = 104.26$, $MSE = 0.05$ (see Table 5). However, in this case, natural words were judged old slightly more often than *HENSION* items, although the effect was not reliable, $F(1, 12) = 3.13$, $MSE = 0.01$. After 15 replications (Whittlesea & Williams, 1998, 2000), this is the first study in which we have not observed more claims of recognition for regular nonwords than words. Failure to find the usual *HENSION* effect is unlikely to be due to the delayed report of recognition, because we have observed the effect following delay in other studies (see Whittlesea & Williams, 2000). Instead, we suspect that the disappearance of the effect resulted from the brief (800 ms) presentation of the probe and the truncation of processing of the probe caused by subsequent presentation of the context item. That suggests that the perception of discrepancy in processing nonwords requires time—that in order to experience surprise, the person has to realize both that their processing was highly fluent and that the item turned out not to be a word, as well as that those two characteristics are inconsistent.

More important for current purposes, the lexical status of the context item had a reliable effect on recognition claims: Probes preceding regular nonwords were claimed old about 13% more often than those preceding words, $F(1, 12) = 18.41$, $MSE = 0.02$. That is, compared to Experiment 4a, the lexical status of the context item had opposite effects when presented after the probe than before it. None of the two- or three-way interactions was reliable ($F < 1$) in all cases.

We have evidence, discussed earlier, that on encountering regular nonwords as probes, people experience them as discrepant. However, in interpreting the present data, we considered the possibility that the subjects did not experience them as discrepant but instead simply noticed their fluency or lexical status. The subjects certainly noticed the latter, because they were required to perform a lexical decision on each context item. However, we cannot imagine how thinking of the *HENSION* items as nonwords would decrease the familiarity of both words and nonwords presented after lexical decision (Experiment 4a) but also increase the familiarity of words and nonwords when lexical decision interrupted the recognition decision (Experiment 4b). Thinking of the lexical status of a context item could conceivably cause the person to expect that the probe would be of the same class; however, in that case we would have observed an interaction such that the effect of the context depended on the match between context and probe items. We further do not think that the effects are due to perceiving the *HENSION* items as less fluent than the words, because Experiment 1 showed that people experience little difference in fluency between them. Moreover, if the subjects simply thought of the *HENSION* items as relatively nonfluent, we should probably have observed the same effect in Experiment 4b as in Experiment 4a.

Instead, we suggest that the subjects experienced the context nonwords as discrepant in both cases. As discussed in the introduction, we assume that the feeling of familiarity, both for words and nonwords, is based on the perception of discrepancy (at least it is when the subjects have time to process the stimuli fully). However, not all words feel simply coherent, and not all regular nonwords feel discrepant: The surprisingness of items will vary, depending on just how easy they are to pronounce and what else comes to mind about that item (or fails to come to mind) to justify that fluency (e.g., meaningfulness, evident similarity to known words, etc.). The consequence is that in making recognition decisions the subjects have to evaluate how surprising their processing of each item is and whether it is surprising enough to attribute it to a source in the past. In Experiment 4a, the context item was presented and judged prior to presentation of the recognition probe. The subjects perceived nonword context items to be discrepant more often than they did word contexts. However, they did not misattribute this perception to the probes (that would cause an increase in hits and false alarms for items following nonwords, just as presentation of nonwords as probes does). Instead, the processing of the context set a local standard for evaluating the surprisingness of the following probe: perception of surprising fluency in the context raised the standard for perceiving the following probe as surprising. As a consequence, nonword context items reduced the impressiveness of perceived discrepancy in the probe, thereby reducing hits and false alarms for both kinds of item. In contrast, in Experiment 4b, the act of recognition had begun before the context was presented (the subject had already seen the recognition probe) but had not been completed (the decision had not yet been made). In this case, discrepancy experienced in processing the context item felt like part of the recognition decision and was misattributed to the probe. In consequence, presentation of regular nonwords caused increased hits and false alarms for both kinds of item.

It is clear that presenting an item that is perceived as discrepant prior to a recognition probe (Experiment 4a) does not produce the revelation effect (higher hits and false alarms). Instead, it produces the opposite effect. The revelation effect thus does not come about through a perception of discrepancy for the context item itself. Nevertheless, these studies suggest a new possible basis for that effect, other than misattribution of the context item's fluency to the fluency of processing the probe. We suggest that when a word like *VINEYARD* is presented in some task, such as anagram solving, prior to presentation of *RAINDROP* as a probe, it sets a local standard for evaluating the fluency of the probe. If the context task is perceived as difficult, the probe may be experienced as surprisingly easy, causing a perception of discrepancy and an illusion of familiarity. This is the same general mechanism that we proposed for the results of Experiment 4a. The reversal of the results would be accounted for by the difference in the subjects' perceptions of their performance in anagram solution versus reading a *HENSION* stimulus, setting different standards for evaluating the probe.

Whether that is the actual basis of the revelation effect, our results suggest that the effect is part of a much larger class of effects of relationship between context and item. Variation in the task or structure of the context item can produce opposite effects on judgments about the probe. So can variation in the temporal relationship between context and probe. We view the current experiments as the bare beginning of a complex investigation of that relationship.

The idea that perceiving discrepancy in the context can influence feelings of familiarity for stimuli encountered in that context may also be extremely important in understanding people's reactions to normal stimuli in strange or unusual environments, such as underwater, on the moon, or in a foreign culture. Further, the reversing effect of presenting nonwords as context before and during a recognition decision suggests that contexts may have two quite different effects on recognition, respectively, through setting a local standard for evaluating the probe and through misattribution of the properties of the context to the probe. Finally, current theories about the revelation effect have focused on the role of the context in biasing decisions about the probe, without much consideration of how the probe itself causes a feeling of familiarity. However, our experiments also manipulated the characteristics of the probes, directly demonstrating that the proximal cause of familiarity is the perception of discrepancy. In attempting to understand the effect of various kinds of context on claims of recognition, it may be very important to keep in mind that those effects occur through modulation of that perception.

General Discussion

Experiment 1 tested the discrepancy-attribution explanation of the *HENSION* effect. In a between-subject design, Experiment 1 demonstrated that there actually is a greater discrepancy between people's perceptions of the fluency and regularity of the *HENSION* stimuli than their perceptions of those characteristics for natural words and irregular nonwords. Experiment 2 demonstrated that the effect of this perception is not limited to linguistic stimuli but can also produce an illusion of familiarity for musical stimuli. Experiment 3 tested another fundamental assumption of the hypothesis—that the inferences people draw about their processing, and the consequent subjective reactions to it, depend on the context in which that processing occurs. The evaluation process that causes subjective reactions takes into account only those aspects of the processing that are made salient by the task. Finally, in Experiment 4, we attempted to integrate our investigation of the discrepancy-attribution hypothesis with studies of the revelation effect. Our results added to the complexity of that effect, suggesting that the effect of context on recognition decisions about probe depends on the task and nature of the context and also on the temporal relationship between the context and probe.

The discrepancy-attribution hypothesis is based on the idea that people construct a global organization of each processing experience, attempting to integrate each aspect of the experience with the others (cf. Jacoby & Whitehouse, 1989; Kahneman & Miller, 1986; Marcel, 1983; Whittlesea, 1997; Whittlesea & Leboe, 2000). This constructive organization occurs simultaneously at many levels, integrating physical features into global percepts and local meanings into general themes. More important to us, this processing also takes into account the implications of the quality of processing among parts of the experience and the relations between the quality of processing and the quality that one could expect given the structural and semantic characteristics of the stimulus and context. Moreover, in attempting to integrate all of these aspects of processing, the evaluation process arrives not only at a conclusion about the global meaning of the event but also at a conclusion about the global coherence of the experience. We suggest that this latter function is the basis of much subjective experience, including the feeling of familiarity.

The idea that feelings of familiarity are based on a perception of discrepancy helps to explain why that feeling occurs for a stimulus in one context but not in another. For example, imagine that you shop for the first time at a particular convenience store.[4] Everything in the store conforms to your general expectation (products, prices, counter, and clerk in uniform), but the specific characteristics are novel (layout of racks, location of products, face of clerk). Your processing of all of these aspects is less fluent than it would be in a store where you shop regularly, but that is coherent with your knowledge that you have never shopped here before. The low fluency thus produces no strong subjective reaction. On a second visit to the store, your processing of all aspects of the situation is more efficient. In particular, your identification of the

[4] This example is clearly similar to Mandler's (e.g., 1980) famous "butcher on the bus." Mandler used that example to differentiate two aspects of processing, within-item integration and extra-item elaboration, that are respectively important for feelings of familiarity versus recall. Our account differs from Mandler's in emphasizing the importance of evaluating the coherence or discrepancy of processing within a context and attributing the coherence or discrepancy to some source. In our example, the same within-item integration may or may not produce a feeling of familiarity, depending on whether the fluency of integration is coherent with expectations raised by the context.

clerk as the person to whom money should be paid is facilitated. However, this increased efficiency of processing is also unsurprising: It is coherent with your knowledge that you have visited this store previously. This encounter also produces no particular subjective reaction: The face of the clerk does not produce a strong feeling of "I know you from somewhere," any more than does his or her uniform or the layout of the store. In contrast, if you instead meet that clerk on a bus, dressed in civilian clothes, you may experience a powerful feeling of familiarity. One's general expectation about a bus is that all passengers should be strangers and hence not fluently processed. The prior experience of the clerk's face may facilitate integration of his or her features into a unitary percept (although probably to a lesser degree than in the store, with support from the uniform and surrounding context). If it does so, the fluency of processing that face will exceed the norm for the bus context. This discrepancy attracts attention to that face and requires explanation. It could be attributed to exceptional quality of the clerk's features and experienced as a feeling of handsomeness. Alternatively, it could be attributed to prior experience. In that case, one will experience a feeling of familiarity. (Stimulated by that feeling, one might go on to regenerate detail of the previous encounter, such as store and uniform, resulting in actual recall, or fail to regenerate such detail, resulting in a continued state of perplexing familiarity.) That is, the fluency of processing is evaluated relative to expectations aroused by the context. The perception of discrepancy between expected and actual fluency causes one to seek a resolution. The feeling of familiarity is the subjective reaction accompanying the unconscious inference that the discrepancy results from prior experience of the stimulus.

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Appendix

Examples of Artificial, Well-Formed Tunes

18,A −3,B −2,C 3,A −2,D 3,C 5,E 2,F 3,E 6,A 3,G 2,F 3,E 2,D 3,C 5,B −5,E −3,A −3
16,E +2,D +3,C +1,D +1,C +1,A 6,E +2,D +3,B 2,C +3,D +2,C +3,A 5,E 2,G 3,A 2
18,E +2,F++2,G +2,E +2,A +7,G +3,F++2,G +3,E +7,E +2,F++2,G +2,E +2,B +4,A +7,E +2,F++2,G +4
18,G −2,B−−2,G −2,B−−2,C 2,D− 2,C 2,B−−7,G 2,B− 2,G 2,B− 2,C +2,D−+2,C +3,B− 4,G 5,D 6
17,C 4,D 4,F 4,C 4,A 4,C +4,D +4,D +2,C +2,E +4,C +4,D 4,A 4,G 2,F 2,D 4,A 4
16,G 5,D 2,E− 2,C 2,F 2,E− 2,D 2,G −6,C 2,D 2,A− 2,C 2,A− 2,B− 2,A− 2,G 4
18,E +2,F++2,G +2,E +2,A +7,G +3,F++2,G +3,E +7,E +2,F++2,G +2,E +2,B +4,A +7,E +2,F++2,G +4
16,G 2,A 2,C 2,E− 4,E 2,E− 2,E 2,C 4,G −2,A −4,G −2,B−−4,A −2,G −2,F −2,E −4

Note. Examples of artificial tunes used in Experiment 1. The first number in each line specifies the number of notes in the tune. Each note has four parameters (e.g., A−+2), consisting of (a) the name of the note (A through G); (b) sharp (+), flat (−) or neutral ( ); (c) lower (−), middle ( ) or upper (+) octave; and (d) duration in hundreds of milliseconds.

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