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Incidental Learning in Music Reading: The Music Contingency Learning Task

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Abstract

The present report investigated whether nonmusicians can incidentally learn musical skills needed for sight-reading. On each trial, participants identified a note name written inside of a note on the musical staff. In Experiment 1, each note was presented frequently with the congruent note name (e.g., “do” with the note for “do”) and rarely with the incongruent names (e.g., “do” with the note for “fa”). With or without deliberate learning instructions, a robust contingency learning effect was observed: faster responses for congruent trials compared to incongruent trials. Participants also explicitly identified the meaning of the note positions more accurately than chance. Experiment 2 ruled out the potential influence of preexisting knowledge on the contingency learning effect by presenting notes most often with an incongruent note name. Robust learning was again observed, suggesting that participants acquired sufficient knowledge of musical notation to produce automatic influences on behavior (e.g., akin to the interference effect previously found in skilled musicians). A congruency effect was additionally observed in Experiment 2, however. Experiment 3 further explored to what extent this congruency effect might be due to prior music knowledge and/or spatial stimulus-response compatibility between note and response locations (analogous to the SMARC effect). Overall, our results open up new avenues for investigating the incidental learning of complex material, musical or otherwise, and for reinforcing learning even further.

1 Introduction

2 Music is a complex ability that involves a range of different cognitive processes (e.g.,
 3 learning, perception, production; Pearce & Rohrmeier, 2012). Not surprisingly, then, during
 4 traditional music instruction a wide range of skills need to be learned, such as familiarization
 5 with the instrument and musical theory. While traditional training is well adapted to the
 6 acquisition of many of these skills, some skills tend to fall behind. One important musical
 7 skill, which takes a considerable amount of time to acquire, is *sight-reading* ability. Sight
 8 reading refers to the ability to look at a new piece of music for the first time and play it while
 9 reading (e.g., without having to memorize or practice the piece beforehand). Typically,
 10 explicit tutoring and deliberate practice are used to teach and improve sight-reading abilities
 11 (Ericsson et al., 1993; Ericsson & Harwell, 2019; Hébert & Cuddy, 2006; Lehmann, 1997;
 12 Mills & McPherson, 2006; Mishra, 2014). However, even after many years of studying sight
 13 reading, these skills are still lacking among many music students (Hargreaves, 1986; Mills &
 14 McPherson, 2006; Scripp, 1995). In this paper, we will introduce a novel approach to aiding
 15 with sight-reading training, intended as a potential supplement to traditional music
 16 instruction. As will be discussed below, our new approach aims to leverage the benefits of
 17 incidental learning procedures (e.g., very rapid learning), rather than deliberate practice, to
 18 facilitate learning. We note in advance that the current research focuses on one component of
 19 sight reading, namely, responding to the note position stimuli with the corresponding actions.

20 The difficulty of sight reading

21 Part of the difficulty in learning to sight read may be due to the complexity of the
 22 task. Indeed, sight reading is a complex skill that relies on different factors (Kopiez & In Lee,
 23 2006, 2008; Lehmann & Kopiez, 2009) and it involves different processes based on the
 24 coding of visual information, motor responses, and visuomotor integration (Gudmundsdottir,
 25 2010). Although the terms “music reading” and “sight reading” are often used

26 interchangeably, the first can be considered as a prerequisite of the second. That is, while
27 music reading mostly refers to the act of reading and decoding musical notation from music
28 sheets, sight reading refers to the complex skill that involves different components such as
29 reading and decoding musical notation (i.e., music reading) and performing (playing) the
30 music directly while reading, that is, without prior practice (Waters et al., 1997; Wolf, 1976).
31 Therefore, it has been defined as a demanding transcription task (Sloboda, 1982, 1985).

32 Schön et al. (2001, 2002) hypothesized that at least three types of translations are
33 involved when musicians read music: singing-like (visual to auditory transcoding), playing-
34 like (visual to motor transcoding), and note-naming-like (visual to verbal transcoding).
35 Accordingly, Stewart et al. (2003) proposed that musicians automatically generate a
36 sensorimotor translation of a spatial code (written music) into a series of motor responses
37 (keypresses). Reading music requires analyzing visual information. In particular, it is
38 necessary to decode the spatial position of the notes on the music staff. While the horizontal
39 location carries information about the duration, the vertical location indicates the pitch
40 (Sergent et al., 1992). Previous research suggested that timing and pitch information (i.e., the
41 horizontal and the vertical positions of the notes on the staff) are perceived and coded
42 separately (Schön et al., 2001, 2002; Stanzione et al., 1990). Here, we focused on the
43 encoding of the vertical position of the notes, a process that has been investigated in some
44 prior research. Sloboda (1976), for instance, compared the performance in a recall task
45 between musicians and nonmusicians. His results showed that nonmusicians were less
46 accurate in recalling a sequence of notes than musicians, suggesting that naming the visual
47 stimulus can be the first step to encode visual material. Perea et al. (2013) further provided
48 evidence that coding the position of the notes relies on more than just visualization. They
49 used a same/different task, in which participants were asked to judge the similarity between
50 two musical sequences. Nonmusicians had worse performance compared to musicians,

51 suggesting that note position coding is quite approximate at early stages of processing
52 compared to more experienced readers.

53 In addition to being a complex task, focal study of sight-reading skills is atypical
54 (Hardy, 1998). Instead, a music practice often involves a focus on mastering music scores,
55 frequently with blocked repetition (Barry, 1992, 2007; Maynard, 2006; Rohwer & Polk,
56 2006), and a music education often focuses on music theory, instrument technique, etc. These
57 are all important skills as well, of course, but sight reading, though a valued skill, is often
58 ignored. One difficulty in teaching sight reading is that students need to automatize the
59 translation of the notes from the page to the actions on the instrument, and for this an
60 enormous amount of novel materials (e.g., music scores) would be needed (Hardy, 1998). For
61 instance, a familiar musical score that the student has already seen and played before is not
62 very useful in practicing the skill of seeing new, unfamiliar material and rapidly playing it
63 while reading.

64 **Automaticity and the Musical Stroop**

65 Though complex, many musicians will eventually automatize their sight-reading
66 skills. Automatizing particular components of a skill is likely to be crucial to learning
67 complex skills and it is often the key for acquiring expertise. For instance, expert chess
68 players are incredible good at reading the board positions, mostly because they can easily and
69 automatically retrieve encoded positions of the chess pieces on the board after years of
70 looking at chessboard configurations (e.g., Saariluoma, 1994).

71 Similarly, musicians can easily and automatically read music notation. A number of
72 studies using *musical Stroop procedures* (Grégoire et al. 2013; see also, Crump et al., 2012;
73 Drost et al., 2005; Stewart, 2005; Zakay & Glicksohn, 1985, for other musical Stroop
74 procedures), comparing performance between musicians and nonmusicians, provided
75 evidence to support the view of music reading being an automatic process for musicians.

76 Some authors (Grégoire et al., 2013, 2014b, 2014a, 2015, 2019) proposed that this
77 automaticity in musicians may be due by the learned associations between note-positions and
78 note-names in musicians. In musical Stroop tasks, participants are presented with a note on
79 the musical staff with a note-name written inside of it, as illustrated in Figure 1. On congruent
80 trials, the meaning of the note-position (task irrelevant) and the note-name (task relevant)
81 match (e.g., “ré” written inside of the note for “ré”). On incongruent trials, the meaning of the
82 note-position and note-name mismatch (e.g., “mi” written inside the note for “la”). Analogous
83 to color-word Stroop tasks (see MacLeod, 1991; MacLeod & MacDonald, 2000, for
84 nonmusical Stroop procedures), musical Stroop procedures measure the automatic influences
85 of previously learned associations between note positions and their note names on reading
86 simple written note names. Although the task was to ignore the note-position (i.e., where the
87 note was presented on the musical staff) and simply respond to the note-name written inside
88 of it, musicians processed the note-position and this had an impact on note-name reading, as
89 indicated by slower and less accurate responses to incongruent trials relative to congruent
90 trials. This phenomenon has been termed the Musical Stroop Effect . Contrary to the Musical
91 Stroop Effect observed in musicians, nonmusicians responded just as quickly to incongruent
92 as to congruent name-note pairs (i.e., no Musical Stroop Effect). This is unsurprising, as
93 nonmusicians have not learned the meaning (or “translation”) of the note positions (i.e., the
94 association between the note-position and note-name) in the first place and are simply
95 reading the written note names (without any possible influence of the note positions).

96 [Figure 1]

97
98 Previous work with musical Stroop procedures studied the influence of the knowledge
99 acquired before participants entered the laboratory. That is, past work has studied the
100 influence of music knowledge that expert musicians already possessed. Our goal is exactly

101 the opposite: to train nonmusicians to acquire music knowledge that they do not yet possess.
102 Unlike previous research using musical Stroop procedure, here we want to demonstrate that
103 by using an incidental training procedure (discussed shortly) nonmusicians can rapidly
104 acquire such automatic influences of music reading akin to the Musical Stroop Effect
105 previously found in skilled musicians. That is, using an incidental training, nonmusicians
106 should show a Musical Stroop Effect, even after very brief training, supporting the idea of a
107 rapid and incidental acquisition of a complex subskill (i.e., music sight-reading skills). We
108 note that although the term “automaticity” has been used to describe many different features
109 of learning (e.g., the need for awareness, attentional and cognitive resource needs, the
110 stimulus- or goal-driven nature of learning; Moors & De Houwer, 2006), it is certainly not
111 our goal to argue that the learning we observe is automatic in all of these senses. Here, we
112 refer to “automaticity” to describe the “automatic” impact of task-irrelevant note positions on
113 performance of another task (i.e., in the same sense that a color-word produces “automatic”
114 influences on color naming in the traditional Stroop procedure; Augustinova & Ferrand,
115 2014). That is, we ask whether it is possible that nonmusicians can rapidly acquire similar
116 automatic influences of sight-reading knowledge on behavior as that observed in the Musical
117 Stroop Effect with musicians that have more extensive musical training.

118 **Incidental contingency learning**

119 Our research applies knowledge from cognitive psychology research, and more
120 specifically from work on human contingency learning. Contingency learning refers to the
121 basic human ability to learn the relationship between two or more events in the environment
122 (e.g., Event B tends to follow Event A, making Event A a predictive cue for Event B; for
123 reviews, see MacLeod, 2019; Schmidt, 2021). In an incidental learning procedure, the
124 participant is not given the explicit goal to learn a regularity. Rather, the participant is asked
125 to engage in one task (e.g., identify a target stimulus), but a regularity exists in the task (e.g.,

126 an informative secondary stimulus or a predictable sequence of stimuli) that, if learned,
127 allows for anticipation of the likely response. We want to specify that here we used the term
128 “incidental” because we refer to the acquisition of new information without the goal to learn
129 (Kerka, 2000). We note that a separate (albeit correlated) issue from the incidental (vs.
130 deliberate) nature of learning is whether participants are aware of what they have learned. For
131 decades, there has been a heated debate about the nature (implicit or explicit) of the
132 knowledge acquired through “implicit” or incidental learning (Cleeremans et al., 1998).
133 Although we will take some measures of awareness in the present report, it is not our goal to
134 discuss this debate in any detail.

135 Previous research suggests that learning the relationship between events occurs
136 automatically, that is, people are sensitive to frequency of occurrence information (Zacks &
137 Hasher, 2002) and to probabilistic patterns (Kelly & Martin, 1994), and simply attending to
138 events is enough for activating learning of the co-occurrence of these events. Furthermore,
139 people are not just sensitive to the co-occurrences around them, but they can learn this
140 information and use it in a variety of tasks (e.g., in language acquisition; see Aslin et al.,
141 1998; Saffran, Aslin, et al., 1996; Saffran et al., 1997; Saffran, Newport, et al., 1996). We
142 note that we not only have a natural sensitivity in detecting the frequency and probability of
143 events, but this sort of incidental learning can also occur very quickly. Indeed, many learning
144 procedures, such as sequence learning (Nissen & Bullemer, 1987; Turk-Browne et al., 2005),
145 artificial-grammar learning (Reber, 1967; for a review, see Pothos, 2007), the Hebb digits
146 task (McKelvie, 1987; Oberauer et al., 2015; Vachon et al., 2018), and hidden covariation
147 detection (Lewicki, 1985, 1986; Lewicki et al., 1992), produce a rapid learning effect.

148 We took particular inspiration from the color-word contingency learning procedure of
149 Schmidt et al. (2007; for related learning procedures, see Carlson & Flowers, 1996; Miller,
150 1987; Mordkoff & Halterman, 2008; Musen & Squire, 1993). Similar to the color-word

151 Stroop procedure (Stroop, 1935), participants are asked to respond to the color of words by
152 pressing a corresponding button, while ignoring the words. However, the words are neutral
153 (unlike the Stroop) and to induce the acquisition of the contingencies, the words are presented
154 most often in one color (e.g., “move” most often in blue) and rarely in the other colors
155 (“move” rarely in red). Although participants are not informed of the contingencies between
156 colors and words and often do not become aware of the manipulation, they respond quicker
157 and more accurately to *high-contingency* trials, where the word is presented with the expected
158 color (e.g., “move” in blue), than to *low-contingency* trials, where the word is presented with
159 an unexpected color (e.g., “move” in red; Schmidt & De Houwer, 2012b). This contingency
160 learning effect can be explained by the greater familiarization with frequently-presented high
161 contingency trials relative to the rarely-presented low contingency trials (Schmidt & De
162 Houwer, 2016a). The learned regularities allow participants to anticipate the responses based
163 on the presented words (Schmidt et al., 2007), thereby facilitating performance if the
164 anticipated high contingency response is, in fact, required. Interestingly, this effect is
165 extremely robust, with essentially all participants showing a numerical effect, and it is
166 acquired almost instantaneously from the start of acquisition (Lin & MacLeod, 2018;
167 Schmidt et al., 2010; Schmidt & De Houwer, 2016).

168 A major part of the reason *why* learning is so rapid in this type of incidental learning
169 procedure is probably due to the fact that participants see a very large number of trials in
170 which a stimulus is presented and they rapidly respond to it. In other words, such procedures
171 allow participants to cram substantial amounts of practice with novel stimuli into a very short
172 time period (e.g., several hundred trials in a 10-15 min). As previously indicated, this is one
173 of the difficulties with training sight reading: traditional practice does not involve seeing a
174 large amount of novel materials in a short time period. In any case, given how rapid and easy
175 it is to learn with this type of incidental learning procedure, a similar approach might be

176 equally effective in the automatization of visuomotor integration for sight-reading
177 performance. In particular, we hypothesize that participants may be able to acquire the
178 associations between note positions and note names, along with the corresponding actions
179 (i.e., which note to play) with similar efficiency. Indeed, learning in this type of incidental
180 learning procedure primarily involves the learning of the association between the task-
181 irrelevant stimulus (in the experiments to be described shortly: the note position) and the
182 response to make (e.g., the key to press on a keyboard), or stimulus-response learning
183 (Geukes et al., 2019; Miller, 1987; Schmidt et al., 2007; Schmidt & De Houwer, 2012a,
184 2016a). This is particularly interesting in the context of sight reading, where automatization
185 of the association between the note position and the action to perform on the instrument is
186 needed. Our studies will therefore follow a similar logic as the color-word contingency
187 learning described above, but with musical materials.

188 We note that incidental or implicit learning tasks have been used to investigate the
189 learning of music materials in prior work. However, this prior work involved the learning of
190 music that we listen to. For instance, many authors studied the implicit acquisition sequence
191 information linked to melody (Saffran et al., 1999, 2000; Tillmann & Poulin-Charronnat,
192 2010), timbre (Bigand et al., 1998), harmony (Bly et al., 2009; Loui et al., 2009; Rohrmeier
193 & Cross, 2009), and rhythm (Brandon et al., 2012; Salidis, 2001; Schultz et al., 2013;
194 Tillmann et al., 2011). In particular, the participants listen to music sequences and the
195 learning of the structures underlying these sequences is then tested. However, the role of
196 implicit or even incidental procedures in acquiring music skills useful for performance (e.g.,
197 how to play) is not clear yet.

198 **The current research**

199 Our adapted musical contingency-learning procedure is a hybridization of the above-
200 mentioned musical Stroop and color-word contingency learning procedures. Our task follows

201 the same structure of the musical Stroop task of Grégoire et al. (2013), in which a note is
202 presented on a musical staff, which we will refer to as the note-position or simply the note.
203 Written inside the note is the name of a note (e.g., “mi”), or note-name. Critically, as
204 illustrated in Figure 1, the note-name can be either congruent with the position of the note
205 (e.g., “ré” written inside the note for “ré”) or incongruent (e.g., “mi” written inside of the note
206 for “la”). However, to induce the learning of the note-name/note-position associations, our
207 task follows the same logic as the color-word contingency learning procedure of Schmidt et
208 al. (2007). In Experiment 1, each note was presented much more frequently with the
209 congruent note-name (18 of 24 presentations, or 75%) than with any of the incongruent note-
210 names (6 of 24 presentations, or 25%). For instance, the note-position for “do” was presented
211 much more often with the note-name “do” than with the note-names “ré”, “mi”, and so on.

212 Participants simply respond as quickly and accurately as possible to the task-relevant
213 stimulus (note-name) while ignoring the task-irrelevant stimulus (note-position). Critically,
214 the note-position is informative in our adaptation (i.e., the note-position is predictive of the
215 probable correct response to the note-name). Thus, learning could occur incidentally, and
216 nonmusicians could learn the keyboard actions to perform for the note positions via the
217 contingencies between the note-positions and responses to the note-names. We note that we
218 use an imperfect contingency manipulation (i.e., not all trials are congruent) because this
219 allows us to measure learning while it is occurring (i.e., by contrasting performance on high-
220 and low-contingency trials; see Discussion for further remarks on this point).

221 Previously in the introduction, music sight-reading has been defined as a
222 transcriptional task, where music symbols are translated into motoric actions (Sloboda, 1982,
223 1985). To study closely the acquisition of this task, we required our participants to respond to
224 the note-names by pressing an assigned key on a computer keyboard. This type of arbitrary
225 stimulus-response assignment is similar to the learning of playing a new musical instrument,

226 where, for instance, a novice musician must learn which keys to press on a piano keyboard
227 for each note.

228 It was anticipated that our incidental learning procedure would allow for rapid
229 automatization of sight-reading skills, primarily because participants can experience a
230 relatively large number of randomized trials with the congruent correspondences between
231 note-positions and the keyboard responses to note-names. However, this is not to say that the
232 deliberate intention to learn will not aid learning further. Schmidt and De Houwer (2012a,
233 2012d) compared the performance in the color-word contingency learning procedure between
234 a deliberate learning group (which was informed of the contingencies present in the
235 paradigm) and an incidental one (which was not informed of the contingencies). Their results
236 showed better performance for the deliberate learning group, suggesting that intentionality
237 plays a role in learning the contingencies (for a similar result in sequence learning, see
238 Destrebecqz, 2004). Therefore, to assess the role of intentionality during learning, in
239 Experiment 1, participants were divided into a deliberate learning group, instructed to pay
240 attention to the contingencies, and an incidental learning group, who received no instructions
241 about the presence of contingencies. It was hypothesized that, most critically, even the
242 incidental learning group would show evidence of learning. However, the deliberate learning
243 group might show even more robust learning.

244 In addition, subjective and objective awareness measures (see Cheesman & Merikle,
245 1984) were taken to assess the verbalizable knowledge of the contingencies acquired by
246 participants. *Subjective awareness* is measured by simply asking participants whether they
247 noticed the contingent regularities. *Objective awareness* is measured by asking participants to
248 forced-choice guess the “name” of each note-position, with awareness indicated by above-
249 chance guessing. The objective awareness test also serves as a “test” phase of verbalizable
250 knowledge of the meaning of the note positions.

251 To summarize, we hypothesized that the incidental contingency learning procedure
252 will help nonmusicians to easily learn the visuomotor translation of music symbols. However,
253 based on previous research (Schmidt & De Houwer, 2012a, 2012d), it is expected that the
254 deliberate intention to learn can help learning even further. Moreover, in a long-term
255 perspective, this research aims to provide the starting point to create a tool that allows
256 nonmusicians (or even experienced musicians) to learn (or improve) sight-reading abilities.

257 **Pilot study**

258 In the interest of full disclosure, we note that we initially conducted a pilot study with
259 41 participants (undergraduate psychology students from the University of Burgundy). The
260 pilot was identical to Experiment 1 below, with two exceptions. First, there was no deliberate
261 learning group (i.e., all participants learned incidentally). Second, the contingency
262 manipulation was much weaker. Specifically, each note was presented only six times more
263 frequently with the congruent note-name than any of the incongruent note-names (instead of
264 18 times more frequently in Experiment 1), meaning that congruent pairings occurred on only
265 50% of trials.

266 The resulting contingency effect was not significant in response times (RTs), $t(40) =$
267 $1.29, p = .205, d = -.201, BF_{10} = .364$, or errors, $t(40) = -1.32, p = .195, d = .206, BF_{10} = .377$,
268 but the difference between low-contingency and high-contingency trials ($M_{\text{low-high}} = 8.28, SD$
269 $= 41.1$) in RTs was encouraging. We thus strengthened the contingency manipulation in
270 Experiment 1, as this should increase the size of the learning effect. For instance, Forrin and
271 MacLeod (2018) showed that the magnitude of the color-word contingency effect is
272 exponentially related to contingency strength. That is, the effect gets much larger the stronger
273 the contingency manipulation is.

274 Thus, for the present study we decided to (a) increase the strength of the contingency
275 manipulation to elicit a larger congruency effect, (b) increase the sample size for more

276 statistical power, and (c) introduce a deliberate learning group to explore the role of
277 intentionality in a musical notation acquisition context. Supplementary material on our pilot
278 experiment can be obtained by following the link: <https://osf.io/fzex7/>.

279

280

Experiment 1

281 In Experiment 1, two main hypotheses are investigated: 1) Based on color-word
282 contingency learning research, it is expected that after a very small amount of practice,
283 nonmusicians should incidentally learn which note-name corresponds to which note-position,
284 and should therefore respond faster to the high-contingency (or “congruent”) pairings relative
285 to the low-contingency (or “incongruent”) pairings, and 2) after a short learning phase, both
286 the participants in the deliberate and incidental learning groups will be able to explicitly read
287 musical notation, performing above chance in the objective awareness test phase.

Method

Participants

290 We recruited 123 undergraduate psychology students at the University of Burgundy.
291 The participants received course credits for their voluntary participation. Participants were
292 randomly assigned to the deliberate and incidental learning groups. Sixty-two participants
293 (deliberate learning group) were asked to focus on the contingencies occurring during the
294 learning phase. The remaining 61 participants (incidental learning group) did not receive any
295 instructions about the contingencies present in the task. Our inclusion criteria were not being
296 a musician and not being able to read musical notation. These inclusion criteria were
297 indicated in the recruitment advertisement. All the procedures were conducted in accordance
298 with the Declaration of Helsinki. A written consent form was signed by all participants before
299 beginning the study. Participants’ anonymization was guaranteed.

300 *Apparatus, Design, and Procedure*

301 In addition to the contingency manipulation, we made some additional changes to the
302 typical musical Stroop procedure to aid learning. First, the musical staff was presented in the
303 center of the screen in one fixed position. In the original experiments of Grégoire et al.
304 (2013), the location of the staff was pseudorandomly varied in the four corners of the screen
305 to prevent iconic memory of the staff. For the present report, however, we were actively
306 aiming to train participants to learn location-to-response correspondences (i.e., note-position
307 to note-name correspondences), so a fixed staff location was deemed desirable. Additionally,
308 the note-position was presented slightly in advance of the note-name. This was done because
309 it is known that advanced presentation of predictive cues boosts learning (Schmidt & De
310 Houwer, 2016), likely because this gives the cue a “head start” to influence identification of
311 the target. Finally, we used manual (key press) responses rather than oral naming responses.
312 This was done, in part, for convenience and, in part, because a less automatic response
313 modality (i.e., arbitrary stimulus-key assignments are slower than simple reading) allows
314 more time for the cue (note-position) to influence responding to the target (Forrin &
315 MacLeod, 2017; Schmidt, 2018). Moreover, as already suggested in the introduction,
316 arbitrary stimulus-key assignments are similar to the motoric response that novice musicians
317 practice when learning to play an instrument.

318 The experiment was programmed and ran with E-Prime 2 (Psychology Software
319 Tools, Pittsburgh, PA) and run on laptops with 1080p resolution. During the main parts of the
320 experiment, participants responded with the Z-I keys on a standard AZERTY keyboard. The
321 keys were labelled according to the sequence of the musical scale from the lower to upper
322 position (i.e., fa, sol, la, si, do, ré, and mi, respectively). The “O” and “N” keys were
323 additionally used to answer “Oui” (Yes) or “Non” (No) to the subjective awareness question,
324 and the spacebar was used to begin each phase from the instruction screens.

325 For stimuli, we used the seven notes from one octave (excluding the repeated octave)
326 but beginning from “fa” (F4) and ending at “mi” (E5), as illustrated in Figure 2. We selected
327 notes from “fa” to “mi” simply to use notes that fit within the main treble staff (i.e., first to
328 fourth space). For instance, the first “do” (C4) falls on one line below the staff and normally
329 is marked with a small strikethrough to indicate the position, which was deemed undesirable.
330 In French, the note names are “do,” “ré,” “mi,” “fa,” “sol,” “la,” and “si”, unlike in English
331 where A-G letter names are typically used. All target stimuli were presented in black 30 pt.
332 Courier New font on a white screen, unless otherwise noted.

333 [Figure 2]

334 The experiment involved five phases. The goal of the first two phases was to allow
335 participants to practice and automatize the note name-to-key assignments before proceeding
336 to the actual learning phase. Results for these phases are not analyzed. In these practice
337 phases, participants were not presented with notes or the musical staff, but only the written
338 note names. In the first of these phases, the trial started with a fixation cross (“+”) in the
339 center of the screen for 500 ms. This was followed by one of the seven the French note-
340 names (*fa*, *sol*, *la*, *si*, *do*, *ré*, or *mi*) presented in the center of the screen until the participant
341 pressed the corresponding response key (no time limit). Following correct responses, the next
342 trial began immediately. Following incorrect responses, the note-name changed color to red
343 (255,0,0; or E-Prime/HTML “red”) and stayed on the screen until the participant pressed the
344 correct key. During the entire trial, the seven key labels (*fa* through *mi*), corresponding to the
345 keyboard response keys, were presented at the bottom of the screen in bold 18 pt. Courier
346 New font with five spaces between each, x-axis centered and below the target (centered at
347 600 px. on the y-axis). No specific instructions were given on how to use the keyboard
348 responses. Each of the seven note names was presented once per block in random order, with
349 ten blocks total (70 trials). The second practice phase was identical in all aspects, except that

350 the on-screen key reminder was removed, and participants were encouraged to try to respond
351 from memory (though the keys on the keyboard remained labelled in case the participant was
352 particularly lost).

353 After these two training phases, and to study whether differences occurred between
354 deliberate and incidental learning, we added an extra instruction screen before the learning
355 phase for half of the participants (deliberate learning group), which instructed them about the
356 contingency manipulation and asked them to try to learn the contingencies. The instructions
357 were (translated from the French version):

358 *Note: Each note will be presented more frequently with the correct note name and less*
359 *frequently with the incorrect note names. Try to learn the note name for each note*
360 *position.*

361 The following third phase was the main learning task used to assess learning in
362 response times and errors. On each trial, participants were presented with the musical staff
363 (see Figure 1), an image of 602 × 909 px. (squished slightly to 602 × 902 px. to better align
364 notes with the staff), which remained centered on the screen throughout the whole trial. At the
365 start of the trial, the empty staff was presented for 500 ms. The note (67 × 100 px.) was then
366 added to the staff for 250 ms, *x*-axis centered at 800 px. and *y*-axis centered either on or
367 between one of the lines for the given note-position (522, 482, 442, 402, 362, 322, or 282
368 px.). The note-name was then written inside the note and participants had 3000 ms to
369 respond. The entire procedure for stimuli appearance during the learning phase is illustrated
370 in Figure 3.

371 [Figure 3]

372 If the participant responded correctly, the next trial began immediately. If they
373 responded incorrectly or failed to respond in 3000 ms, the note name was replaced with
374 “XXX” in red for 500 ms. During the learning phase, there were two blocks of 168 trials (336

375 trials in total), each randomly ordered (without replacement) and there was no break between
376 the two blocks. Each note was presented 18 times per block with the congruent note-name
377 (e.g., “fa” in the note for fa) and once each with the remaining six note names (e.g., “fa” in
378 the note for do). Thus, each congruent name-note pairing was more frequent (high
379 contingency) than each incongruent name-note pairing (low contingency). The congruency
380 (or contingency learning) effect was measured as the difference between low and high
381 contingency RTs (and errors).

382 Following the main learning phase, we additionally collected contingency awareness
383 data to assess the awareness of participants of the contingency manipulation in the final two
384 phases. In particular, participants were assessed for both subjective and objective awareness
385 (Cheesman & Merikle, 1984). Respectively, *subjective awareness* is defined as a participant’s
386 ability to verbally describe their experience, while *objective awareness* is defined by a
387 participant’s ability to discriminate (e.g., better-than-chance guessing) between experienced
388 and unexperienced events. For the *subjective awareness* measure (i.e., the fourth phase), the
389 on-screen instructions told participants (translated from French):

390 *During the third part of this experiment, note names were written inside the notes.*

391 *Each note was presented more frequently with one note name than the others. That is*

392 *to say, one note was frequently presented with “do,” another frequently with “re,”*

393 *etc. Did you notice these regularities?*

394 Participants could respond “yes” or “no” with a key press.

395 Directly after, we introduced the *objective awareness* measure test phase (i.e., the fifth
396 and final phase) as a more explicit test of verbalizable knowledge to (a) test whether the
397 association between note-position and note-name was acquired, and (b) investigate whether
398 the information incidentally acquired could be expressed explicitly. The phase began with the
399 following instructions (translated from French):

400 *Now, the task is similar, except that you will only see a note (not a note-name). Try to*
401 *guess the name of the note by pressing the appropriate key on the keyboard.*

402 The task was similar to the learning phase, except that (a) only the note-positions
403 (without note-names) were presented, (b) the on-screen key reminder was re-added below the
404 musical staff (y -axis centered on 775 px.), (c) there was no time limit to respond, and (d)
405 there was no accuracy feedback. Thus, participants had to respond to the notes themselves
406 (previously task irrelevant) rather than to the note-names. There were three blocks of each of
407 the seven notes (21 trials in total), presented randomly without replacement.

408 ***Data Analysis***

409 Analyses of the learning phase were conducted on mean correct RTs and error rates.
410 Trials in which participants failed to respond in 3000 ms (i.e., the response deadline) were
411 eliminated. Repeated measures ANOVAs for RTs and for error rates were conducted to assess
412 the overall main effects of contingency, instruction, and the interaction between them.
413 Furthermore, we ran another repeated measures ANOVA for RTs and error rates with the
414 added factor of block (Block 1 and Block 2) to assess the presence of a contingency effect
415 from the start of the acquisition process. If this is the case, we expect no significant
416 interaction between blocks and contingency. One-sample t tests were used to assess learning
417 rates between the groups. Pearson's correlations were performed to assess relations between
418 objective and subjective awareness and the contingency effect. All analyses were evaluated at
419 the $\alpha = .05$ level of significance. Additionally, we estimated the Bayes factor for all the data
420 using JASP software (JASP Team, 2019). All the Bayesian analyses were done using the
421 standard noninformative Cauchy prior in JASP with a default width of 0.707. A BF_{10} between
422 3 and 10 allows us to conclude that we have moderately strong evidence for H_1 . The data set
423 and R script are available via the following link: <https://osf.io/fzex7/>.

424 **Results**425 **Response Times**

426 The RT results for Experiment 1 are presented in Figure 4. A repeated measures
427 ANOVA for RTs with the factors Contingency (high vs. low) and Group (deliberate vs.
428 incidental) showed a significant main effect of Contingency, $F(1, 121) = 32.347, p < .001, \eta^2$
429 $= .211, BF_{10} > 100$, indicating faster responses for high-contingency trials ($M = 855$ ms, $SD =$
430 112) than for low-contingency trials ($M = 877$ ms, $SD = 115$).

431 [Figure 4]

432 The main effect of Group was not significant, $F(1, 121) = .580, p = .448, \eta^2 = .005,$
433 $BF_{10} = .554$. Interestingly, the interaction between Contingency and Group was also not
434 significant, $F(1, 121) = .797, p = .374, \eta^2 = .007, BF_{10} = .278$, indicating no significant
435 differences between deliberate vs. incidental learning groups for the contingency effect,
436 although the effect was numerically larger for the deliberate learning group (see Figure 4;
437 $M_{\text{low-high}} = 25.7, SD = 38.4; t(61) = 5.25, p < .001, d = .667, BF_{10} > 100$) compared to the
438 incidental one ($M_{\text{low-high}} = 18.7, SD = 47.6; t(60) = 3.07, p = .003, d = .393, BF_{10} = 9.320$).

439 Additionally, a repeated measures ANOVA for RTs with the factors Block (1 vs. 2),
440 Contingency (high vs. low), and Group (deliberate vs. incidental) was computed to analyze
441 the data for rapid acquisition of the contingencies and possible differences across blocks
442 between the two groups. A significant main effect for Blocks was found, $F(1, 121) = 44.053,$
443 $p < .001, \eta^2 = .267, BF_{10} > 100$, showing significantly faster RTs in Block 2 ($M = 849$ ms, SD
444 $= 117$) compared to Block 1 ($M = 884$ ms, $SD = 115$), indicating a standard practice effect on
445 mean RT. The main effect for Contingency was also significant, $F(1, 119) = 32.363, p < .001,$
446 $\eta^2 = .211, BF_{10} > 100$.

447 [Figure 5]

448 Block and Contingency did not interact, $F(1, 121) = .543, p = .463, \eta^2 = .004, BF_{10} =$

449 .277, suggesting that the learning of contingencies is fast rather than appearing gradually
 450 across blocks. On the other hand, the interaction between Block and Group was significant,
 451 $F(1, 121) = 9.839, p = .002, \eta^2 = .075, BF_{10} = 95.284$. Specifically, as illustrated in Figure 5,
 452 we found a significant difference in RTs for the deliberate learning group ($M_{\text{Block 1-Block 2}} =$
 453 $50.65; t(121) = 6.939, p < .001$). This difference was not significant for the incidental
 454 learning group ($M_{\text{Block 1-Block 2}} = 18.14; t(121) = 2.465, p = .091$). Finally, the Contingency \times
 455 Block \times Group interaction was not significant, $F(1, 121) = .279, p = .599, \eta^2 = .002, BF_{10} =$
 456 .190

457 ***Error Rates***

458 A repeated measures ANOVA for errors with the factors Contingency (high vs. low)
 459 and Group (deliberate vs. incidental) did not reveal a main effect of Contingency, $F(1, 121) =$
 460 $.081, p = .776, \eta^2 = .001, BF_{10} = .145$, or Group, $F(1, 121) = .115, p = .735, \eta^2 = .001, BF_{10} =$
 461 $.291$. The interaction between Contingency and Group was also not significant, $F(1, 121) =$
 462 $.015, p = .901, \eta^2 = 0.00, BF_{10} = .186$ (deliberate learning group, $M_{\text{high}} = .976, SD = .025, M_{\text{low}}$
 463 $= .990, SD = .029$; incidental learning group, $M_{\text{high}} = .977, SD = 0.027, M_{\text{low}} = .980, SD =$
 464 $.025$). Given the lack of a contingency effect in errors, a block analysis was not performed.

465 ***Subjective and objective awareness***

466 For the subjective awareness question, 33 of 62 participants (53%) in the deliberate
 467 learning group reported that they noted the regularities, and 27 of 61 participants (44%) in the
 468 incidental learning group. Subjective awareness rates were not significantly different between
 469 the two groups, $M_{\text{deliberate-incidental}} = 9\%, t(121) = .990, p = .324, d = .179, BF_{10} = .300$
 470 (deliberate learning group: $M = 53\%$; incidental learning group: $M = 44\%$).

471 Using one-sample t tests, we found that the rates of objective awareness (test phase
 472 accuracy) were above chance (1/7 or 14.3%) in both groups: deliberate learning group ($M =$
 473 $50.6\%, SD = 31.1, t(61) = 9.19, p < .001, d = 1.17, BF_{10} > 100$, incidental learning group ($M =$

474 = 32.0%, $SD = 27.7$), $t(60) = 4.98$, $p < .001$, $d = .637$, $BF_{10} > 100$. Objective awareness was
475 higher for the deliberate learning group than for the incidental learning group, and a Welch
476 two-sample t test showed that this 19% differences between the two groups was significant,
477 $t(120) = 3.51$, $p = .001$, $d = .633$, $BF_{10} = 42.530$.

478 [Figure 6]

479 The RT-contingency effect (i.e., low minus high contingency) correlated significantly
480 with both subjective awareness, $r(121) = .239$, $p = .008$, $BF_{10} = 3.760$, and objective
481 awareness, $r(121) = .401$, $p < .001$, $BF_{10} > 100$, as shown in Figure 6. Additionally, the
482 contingency effect was significant for both participants who were subjectively aware ($M =$
483 32.7 , $SD = 48.1$), $t(59) = 5.28$, $p < .001$, $d = .681$, $BF_{10} > 100$, and for those who declared to
484 be unaware ($M = 12.2$, $SD = 35.5$), $t(62) = 2.72$, $p = .009$, $d = .342$, $BF_{10} = 3.941$, suggesting
485 stronger contingency effect for participants with greater awareness. For the objective
486 awareness factor, we also computed the regression intercept at chance guessing (Greenwald
487 et al., 1995). That is, we calculated a regression with objective awareness as the predictor and
488 the RT contingency effect as the dependent variable. Objective awareness was re-centered at
489 chance guessing (1/7, or 14.3%). The intercept therefore indicates the size of the contingency
490 effect when participants are guessing at chance in the objective awareness phase. This
491 intercept was numerically above zero in the sample as a whole (intercept $M = 6.989$), but not
492 significantly, $t(121) = 1.46$, $SE = 4.78$, $p = .146$, $BF_{10} = 1.0$. Globally, the data show an
493 impact of contingency knowledge on the size of the RT contingency effect, though it remains
494 unclear whether and to what degree implicit learning also contributes to the effect. In contrast
495 to the RT data, the error contingency effect (low minus high contingency errors) was not
496 correlated with subjective awareness, $r(121) = -.018$, $p = .845$, $BF_{10} = .115$, or objective
497 awareness, $r(121) = .001$, $p = .993$, $BF_{10} = .113$, which is not surprising given the lack of a
498 significant contingency effect in errors.

499 ***Discussion***

500 As hypothesized, in Experiment 1 we found a contingency effect, suggesting that
501 nonmusicians were able to incidentally learn the associations between note-positions and the
502 keyboard responses to note-names. Furthermore, in line with previous research, the block
503 analysis suggests a rapid acquisition of the contingencies starting from the beginning of the
504 learning phase. Although both groups responded significantly higher than chance in the
505 objective awareness phase, the deliberate learning group was more accurate than the
506 incidental one. This result may indicate an influence of attention in explicitly reporting the
507 new acquired information. Overall, a relationship between the contingency effect and
508 awareness was revealed by the significant correlations.

509

510 **Experiment 2**

511 Experiment 2 addresses a potential caveat with Experiment 1. It may be argued that
512 the contingency effect in Experiment 1 can be due to previous implicit knowledge about note-
513 name/note-position associations, rather than contingency learning. Although participants
514 claimed that they were not able to read music notation, it is possible that they studied music
515 at school and remember more than they imagined or even that some musicians
516 misrepresented their music reading abilities in order to participate. If this were true, then it
517 could be the case that no actual learning occurred in Experiment 1. Therefore, to address this
518 concern and to also investigate whether previous musical knowledge influences the effect, we
519 ran a second experiment. Experiment 2 was identical to Experiment 1, except that the high-
520 contingency pairings were no longer the congruent pairings. Each note position was
521 presented more often with one of the six incongruent note names (e.g., “ré” written inside the
522 note for “fa”) on high-contingency trials and rarely with the remaining congruent and
523 incongruent names (e.g., “ré” written inside the note for “ré”) on low-contingency trials.

524 Participants were divided in six groups, such that across participants every note position
525 *except* the congruent note was high contingency for a given note name.

526 Unlike Experiment 1, in Experiment 2 contingency was different from congruency.
527 The congruent trials (e.g., “ré” written inside the note for “ré”) were presented much less
528 often than the high-contingency incongruent trials (e.g., “ré” written inside the note for “fa”).
529 Therefore, in Experiment 2 we speak about both the contingency effect (low minus high
530 contingency trials) and the congruency effect (incongruent minus congruent trials). If
531 previous musical knowledge is not present, the scrambling of the note-name to note-position
532 associations should not be important, and we anticipate that participants will show a
533 contingency effect similar to the one found in Experiment 1 (faster RTs for high-contingency
534 trials compared to low-contingency trials). On the contrary, if participants possess
535 undisclosed previously-acquired musical knowledge, then we should anticipate a congruency
536 effect (faster RTs for congruent trials compared to incongruent ones) despite the high vs. low
537 contingency presentation. Of course, it is also possible that both effects will be observed: a
538 true learning effect within the experiment in addition to a congruency effect due to
539 undisclosed sight-reading knowledge.

540 **Method**

541 *Participants*

542 Experiment 2 took place during the Covid-19 pandemic, so to adhere to the general
543 health recommendations that restricted the possibility to recruit new participants to come to
544 the lab, we ran Experiment 2 using the online Prolific.co platform. 132 participants clicked to
545 start the experiment, but we excluded participants who abandoned the experiment before
546 completion or did not actually begin the task. The remaining 60 participants, who received
547 monetary compensation (£2) for their participation, were randomly assigned to each of the six
548 scrambled note-name/note-position conditions, described below. Each condition was

549 composed of 10 participants. The inclusion criteria were the same as those used for
550 Experiment 1 and they were mentioned in the recruitment advertisement. All the procedures
551 were conducted in accordance with the Declaration of Helsinki. A consent form was signed
552 by all participants before beginning the study. Participants' anonymization was guaranteed.

553 *Apparatus, Design, and Procedure*

554 The experiment was programmed and run with Psytoolkit (Stoet, 2010, 2016). The
555 structure of Experiment 2 was basically the same as Experiment 1, with the following
556 exceptions. All participants learned incidentally, as in the incidental learning group of
557 Experiment 1. Thus, no instruction about the contingencies was given. In the learning phase,
558 we used scrambled note-name/note-position associations. That is, each note was presented 18
559 times per block with one of the incongruent note-name pairing (e.g., "ré" in the note for "fa")
560 and once each with the remaining congruent and incongruent note-name pairings (e.g., "ré" in
561 the note for "ré" and "ré" in the note for "do"). Thus, one specific incongruent name-note
562 pairing was more frequent (high contingency) than the congruent and each remaining
563 incongruent name-note pairings (low contingency). We created six groups by shifting the
564 name-position correspondences by 1, 2, 3, 4, 5, or 6 tones (e.g., the position "ré" most often
565 with the name "mi", "mi" most often with "fa", etc. for Group 1; the position "ré" most often
566 with "fa", "mi" most often with "sol", etc. in Group 2; etc.). Thus, across participants all note
567 positions were high contingency with each note name, except the congruent pairing.

568 *Data Analysis*

569 The same data analysis criteria used in Experiment 1 were applied for Experiment 2
570 with some exceptions: no block ANOVA was assessed; no instruction factor was used since
571 all participants learned incidentally in Experiment 2. However, we ran a repeated measures
572 ANOVA with Congruency as factor to evaluate the influence of congruent vs. incongruent
573 trials on the learning process. High-contingency incongruent trials were eliminated from this

574 analysis, so that the low-contingency congruent trials were compared only to low-
575 contingency incongruent trials. The data set and R script are available via the following link:
576 <https://osf.io/fzex7/>.

577 **Results**

578 ***Response Times***

579 The RT results for Experiment 2 are presented in Figure 7. The repeated measures
580 ANOVA for RTs with Contingency (high vs. low) and Group (1, 2, 3, 4, 5, 6) as factors,
581 showed a significant main effect of Contingency, $F(1, 54) = 55.284, p < .001, \eta^2 = .506, BF_{10}$
582 > 100 (high-contingency trials, $M = 988$ ms, $SD = 207$; low-contingency trials, $M = 1036$ ms,
583 $SD = 206$). The main effect of Group was not significant, $F(5, 54) = 1.05, p = .400, \eta^2 = .088,$
584 $BF_{10} = .527$, and the interaction between Contingency and Group was also not significant,
585 $F(5, 54) = .565, p = .726, \eta^2 = .050, BF_{10} = .064$, suggesting no differences between groups
586 for the contingency effect.

587 [Figure 7]

588 Interestingly, when using Congruency (congruent vs. incongruent) and Group (1, 2, 3,
589 4, 5, 6) as factors, the repeated measures ANOVA for RTs showed a significant main effect of
590 Congruency, $F(1, 54) = 4.668, p = .035, \eta^2 = .080, BF_{10} = 1.598$ (congruent trials, $M = 996$
591 ms, $SD = 201$; incongruent trials, $M = 1045$ ms, $SD = 219$). The main effect of Group was not
592 significant, $F(5, 54) = 1.55, p = .190, \eta^2 = .126, BF_{10} = .674$, as was the interaction between
593 Congruency and Group, $F(5, 54) = .411, p = .839, \eta^2 = .037, BF_{10} = .100$.

594 ***Error Rates***

595 The repeated measures ANOVA for errors with Contingency (high vs. low) and Group
596 (1, 2, 3, 4, 5, 6) as factors did not reveal a main effect of Contingency, $F(1, 54) = 1.267, p =$
597 $.265, \eta^2 = .023, BF_{10} = .329$ ($M_{\text{high}} = 9.74, SD = 8.70; M_{\text{low}} = 10.3, SD = 10.5$), or Group, $F(5,$
598 $54) = 1.17, p = .335, \eta^2 = .098, BF_{10} = .442$. The Contingency by Group interaction was also

599 not significant, $F(5, 54) = .875, p = .504, \eta^2 = .075, BF_{10} = .137$.

600 Surprisingly the repeated measures ANOVA for errors with Congruency (congruent
601 vs. incongruent) and Group (1, 2, 3, 4, 5, 6) as factors showed a significant main effect of
602 Congruency, $F(1, 54) = 6.54, p = .013, \eta^2 = .108, BF_{10} = 1.614$ ($M_{\text{congruent}} = 7.86, SD = 9.18$;
603 $M_{\text{incongruent}} = 10.8, SD = 11.4$). The main effect of Group was not significant, $F(5, 54) = .797$,
604 $p = .557, \eta^2 = .069, BF_{10} = .095$, nor was the Congruency by Group interaction, $F(5, 54) =$
605 $2.12, p = .078, \eta^2 = .164, BF_{10} = .674$.

606 **Subjective and objective awareness**

607 In Experiment 2, more than 50% of the participants (34 of 60) reported to be aware of
608 the regularities. Overall, the rates of objective awareness (test phase accuracy) were above
609 chance (1/7 or 14.3%), ($M = 23.2\%, SD = 26.5$) $t(59) = 2.60, p = .006, d = .335, BF_{10} =$
610 3.018 . The correlations between the RT-contingency effect (i.e., low minus high contingency)
611 and subjective awareness, $r(58) = .123, p = .350, BF_{10} = .247$, and objective awareness, $r(58)$
612 $= .085, p = .519, BF_{10} = .197$, were not significant. Additionally, the contingency effect was
613 significant for both participants who were subjectively aware ($M = 42.9, SD = 57.5$), $t(33) =$
614 $4.35, p < .001, d = .746, BF_{10} > 100$, and for those who declared to be unaware ($M = 55.0, SD$
615 $= 35.5$), $t(25) = 7.90, p < .001, d = 1.55, BF_{10} > 100$.

616 [Figure 8]

617 The congruency effect correlated significantly with subjective awareness, $r(58) =$
618 $.345, p = .007, BF_{10} = 5.671$, but not with objective awareness, $r(58) = -.057, p = .668, BF_{10}$
619 $= .176$, as shown in Figure 8. Moreover, the congruency effect was not significant for
620 participants who were subjectively aware ($M = -2.14, SD = 158$), $t(33) = -.079, p = .938, d =$
621 $-.013, BF_{10} = .148$, but was significant for those who declared to be unaware ($M = 116, SD =$
622 165), $t(25) = 3.56, p = .002, d = .699, BF_{10} = 23.940$. As for Experiment 1, we computed a
623 regression intercept at chance guessing (Greenwald et al., 1995) with the objective awareness

624 factor. The result showed a significant intercept above zero, $t(54) = 6.934$, $SE = 6.735$, p
625 $<.001$, $BF_{10} = 1.0$; intercept $M = 46.707$, suggesting that implicit learning contributed to the
626 contingency effect.

627 Not surprisingly, the error contingency effect (low minus high contingency errors)
628 was not significantly correlated with subjective awareness, $r(58) = -.155$, $p = .238$, $BF_{10} =$
629 $.318$, or objective awareness, $r(58) = .122$, $p = .353$, $BF_{10} = .245$. The error congruency effect
630 was also not significantly correlated with subjective awareness, $r(58) = .217$, $p = .096$, $BF_{10} =$
631 $.621$, or objective awareness, $r(58) = -.000$, $p = .998$, $BF_{10} = .161$.

632 Discussion

633 In Experiment 2, we again observed a contingency learning effect. Unlike in
634 Experiment 1, however, the high-contingency pairings were (specific) incongruent pairings in
635 Experiment 2. Thus, preexisting sight-reading knowledge could not have produced this
636 contingency learning effect. Indeed, any preexisting knowledge would actually work *against*
637 a contingency learning effect, as the congruent pairings were low contingency. Interestingly,
638 we did also observe a congruency effect when comparing the congruent and incongruent low
639 contingency pairings. This is a bit surprising given that past reports have failed to observe a
640 congruency effect in nonmusicians (e.g., Crump et al., 2012; Drost et al., 2005; Grégoire et
641 al., 2013; Stewart, 2005). Similarly, we did not find a robust contingency effect for congruent
642 pairings in our other studies with the present paradigm when the contingency manipulation
643 was too weak (including our pilot study and data from one of the conditions of some of our
644 follow-up work to the present report). The reason for this congruency effect is unclear. One
645 possible interpretation is that some of the participants did have prior sight reading knowledge
646 and failed to disclose this, but Experiment 3 will explore this and another potential
647 interpretation.

648 Subjective but not objective contingency awareness was poorly correlated with the

649 contingency effect. Some evidence for implicit learning contributions to the contingency
650 effect were observed, including a significant contingency effect for subjectively unaware
651 participants and a significantly positive intercept in the objective awareness data, which
652 contrasts slightly with the results of Experiment 1. Participants also guessed at above-chance
653 rates the interpretations of the note positions. Of course, these were technically the incorrect
654 note interpretations (i.e., consistent with the incongruent contingencies).

655

656

Experiment 3

657 As previously mentioned, we were surprised to find a significant congruency effect in
658 Experiment 2. As mentioned above, this congruency effect may have been due to the
659 inclusion of some participants that did have preexisting sight-reading knowledge that they
660 failed to disclose (e.g., due to underestimation of their knowledge). However, there may be
661 another explanation for the congruency effect that does not assume that some of the
662 participants had preexisting knowledge. Indeed, it is possible that a congruency effect might
663 be observed even if participants do not know the association between note names and note
664 positions. Instead, there may have been an inherent spatial compatibility between the down-
665 to-up organization of the note positions and the left-to-right organization of the response
666 keys.

667 Previous research (Rusconi et al., 2006) showed the presence of a SMARC (Spatial–
668 Musical Association of Response Codes) effect, defined by the authors as “a variant of the
669 well-known orthogonal stimulus-response compatibility effect, that is a preferential mapping
670 of spatially lower stimuli on left responses and higher stimuli on right responses” (Rusconi et
671 al., 2006, p. 14). For the authors, the SMARC effect reflects the spatial coding of pitches,
672 with the highest pitches represented on the right and the lowest pitches on the left.

673 Recently, Ariga and Saito (2019) showed the presence of a SMARC effect in the absence of
674 pitch. Although, in their study there was no auditory stimulation, the effect was elicited by
675 written pitch names alone for both trained musicians and musically naïve participants.
676 Overall, this evidence suggested that the human cognitive system automatically codes pitches
677 spatially.

678 Therefore, regarding our results, it is possible that the congruency effect could be
679 explained by a natural inclination to spatially code pitches. Indeed, the spatially lowest note
680 position (fa) corresponded to the leftmost response (Z) in our prior experiments moving up to
681 the highest note position (mi) with the rightmost response (I). As such, it could be that
682 participants responded faster to the congruent pairings not because they knew the
683 interpretation of the note positions, but because of the spatial compatibility between the
684 stimulus and response locations. To test this hypothesis, we ran a third experiment. It is worth
685 noting that the aim of this third experiment is not to further investigate the contingency
686 learning effect that we observed in the prior two experiments; rather, we aim to test whether
687 the congruency effect found in Experiment 2 was due to preexisting sight-reading knowledge
688 or to a SMARC-like compatibility effect.

689 Experiment 3 was identical to the previous two experiments, except that no
690 contingency manipulation was used. Each note-name/note-position pairing was presented the
691 same number of times. However, to test the hypothesis of the presence of the SMARC effect
692 we distinguished between congruent trials, compatible trials, and control trials (see Table 1
693 and the method section for more details). In particular, the response options were reordered
694 such that the congruent response was *not* spatially compatible with the note position. For
695 instance, the bottommost stimulus location (fa) was *not* the leftmost response. Congruent
696 trials were therefore the trials in which the note position was presented with the true note
697 name (e.g., the position for fa presented with “fa”), compatible trials were not congruent but

698 were spatially compatible (e.g., the position for fa with the note name “do”), and all
699 remaining pairings were controls. If participants do not possess undisclosed previously
700 acquired musical knowledge, then we should not find a congruency effect (faster RTs for
701 congruent trials compared to control ones). If participants are influenced by spatial
702 compatibility, however, then we might find a compatibility effect (RTs faster for the
703 compatible trials compared to control trials).

704 [Table 1]

705 **Method**

706 *Participants*

707 Experiment 3 was coded using Psytoolkit (Stoet, 2010, 2016) and run using the online
708 Prolific.co platform. One hundred and seventy-five participants clicked through to the link to
709 the experiment on Prolific, but we again excluded participants that did not complete the study
710 or actually begin it. 119 participants, who received monetary compensation (£2), took part in
711 the experiment. The inclusion criteria were the same used for Experiment 1 and they were
712 mentioned in the recruitment advertisement. All the procedures were conducted in accordance
713 with the Declaration of Helsinki. A consent form was signed by all participants before
714 beginning the study. Participants’ anonymization was guaranteed.

715 *Apparatus, Design, and Procedure*

716 Experiment 3 was identical to Experiment 2 with the following exceptions. During the
717 “learning phase”, no contingency manipulation was used. That is, each note position was
718 presented equally often with all of the note names. Thus, there was actually no regularity to
719 learn in the present experiment. Instead, we manipulated spatial compatibility and
720 congruency. To dissociate the two, we changed the order of the key mappings. While the
721 down-to-up note positions still went from “fa” to “mi”, the key mappings went from “do” to
722 “si”. In this way, the leftmost response (e.g., do) did not correspond to the bottommost note

723 position (fa). None of the note positions were spatially compatible with the congruent
724 response. Therefore, we distinguished between: (a) *congruent trials*, in which the note name
725 (e.g., “do”) was written in the congruent note position (e.g., “do”), (b) *compatible trials*,
726 where the note name was spatially compatible with the order of the key mapping (e.g., the
727 leftmost note name “do” written in the bottommost note position “fa”), and (c) *control trials*,
728 which were neither congruent nor spatially compatible (e.g., the leftmost note name “do”
729 written in the topmost position “si”). Concretely, the responses were shifted three places to
730 the left, but otherwise maintained the same relative order (i.e., do, ré, mi, fa, sol, la, si).
731 Hypothetically, it would have been possible to create six such orders (e.g., analogous to
732 Experiment 2). However, we opted for this single ordering because for many of the possible
733 orders the congruent and spatial compatible responses would be very close to each other
734 spatially. The particular response ordering that we used maximally separates the congruent
735 and compatible responses. Furthermore, no subjective awareness phase was shown because
736 of the lack of contingency manipulation. A phase effectively identical to the objective
737 awareness phases of the previous experiments was still included, but was no longer a true
738 “awareness” phase (as there was no contingency to be aware of this time). We will therefore
739 refer to this simply as the “test” phase.

740 ***Data Analysis***

741 The same data analysis criteria as those used in Experiments 1 and 2 were applied in
742 Experiment 3. We use *t* tests to compare RTs and error rates between the different trials:
743 congruency, compatibility, and control. We also ran analyses on both the accuracy for
744 congruency and the accuracy for compatibility in the test phase to study whether participants
745 indicated the congruent and/or compatible responses more often than one would expect by
746 chance. Given the absence of a contingency, participants should only indicate the congruent
747 response more often than chance if they have preexisting sight-reading knowledge and should

748 only indicate the compatible response more often than chance if they are influenced by spatial
749 compatibility. The data set and R script are available via the following link:

750 <https://osf.io/fzex7/>.

751 **Results**

752 ***Response Times***

753 The *t*-tests analyses revealed no significant difference in RTs (Figure 9) between
754 congruent and control trials ($M_{congruent-control} = 7.114$, $SD = 58.5$), $t(117) = 1.322$, $p = .189$, $d =$
755 $.121$, $BF_{10} = .329$, or between compatible and control trials ($M_{compatible-control} = -.755$, $SD =$
756 58.9), $t(117) = -.143$, $p = .887$, $d = -.013$, $BF_{10} = .104$.

757 [Figure 9]

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759 ***Error Rates***

760 The *t*-tests analyses revealed no significant difference for error rates between
761 congruent and control trials ($M_{congruent-control} = .730$, $SD = 4.82$), $t(117) = 1.645$, $p = .103$, $d =$
762 $.151$, $BF_{10} = .304$, or between compatible and control trials ($M_{compatible-control} = .307$, $SD =$
763 4.01), $t(117) = .831$, $p = .408$, $d = .076$, $BF_{10} = .164$.

764 ***Test phase***

765 The *t* tests on accuracy rates in the test phase (akin to the objective awareness phase in
766 the previous experiments) revealed accuracy rates that were significantly above chance (1/7
767 or 14.3%) for both the congruent response ($M = 24.7\%$, $SD = 28.1$), $t(117) = 4.00$, $p > .001$, d
768 $= .368$, $BF_{10} > 100$, and the compatible response ($M = 19.6\%$, $SD = 20.4$), $t(117) = 2.80$, $p =$
769 $.003$, $d = .258$, $BF_{10} = 8.334$. Both of these effects, especially the congruency effect, seem to
770 be due to a small number of outliers. Figure 10 shows the distribution of the results in the test
771 phase. As can be seen, most of the participants seemed to be guessing (i.e., their results are
772 under or slightly above chance guessing). However, few of them seemed to have enough

773 preexisting knowledge about the congruency between note names and note positions, with
774 some participants “guessing” 100% of the pairings correctly. Given that there was no way to
775 *learn* the congruent pairings in the present experiment, this clearly indicates preexisting
776 knowledge. The compatibility effect seems similar, but weaker, with an even smaller number
777 of participants indicating the spatially compatible response well above chance.

778 [Figure 10]

779 ***Discussion***

780 In Experiment 3, we tested for possible influences of the SMARC effect on the
781 congruency effect we observed in Experiment 2. That is, we wanted to study whether the
782 natural tendency of spatially coding the pitches could influence participants’ responses in an
783 incidental Stroop-like task. Our results did not show a significant difference in response times
784 between spatially compatible and control trials. Interestingly, we also did not replicate the
785 congruency effect in response times or errors despite a notably larger sample size. As already
786 discussed, this absence of a congruency effect is actually consistent with a number of prior
787 reports with a similar or (in some cases) near identical procedure. The significant congruency
788 effect observed in Experiment 2 may therefore have been a Type 1 error.

789 On the other hand, the nonmusicians responded significantly above chance in the test
790 phase with the congruent response. Given that there was no way for participants to learn the
791 congruent pairings without the current experiment, this clearly indicates that some small
792 number of participants *did* have preexisting sight-reading knowledge. The same test phase
793 also revealed elevated numbers of spatially compatible responses. These latter results may
794 suggest that the natural inclination for spatially coding pitches can influence performance in
795 some cases, such as in a more explicit judgement task.

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General Discussion

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In our study, we were interested in investigating early acquisition of sight-reading skills in an incidental learning procedure. That is, can nonmusicians with no prior familiarity with music reading rapidly acquire knowledge of standard notation that in turn produces automatic influences on performance in a similar way to that observed in skilled musicians? As hypothesized, despite a very short learning phase (336 trials, approximately 15 min) and slightly more complex material than those used in previous incidental learning procedures (e.g., words and colors), nonmusicians produced a robust contingency effect during the learning and subsequent test phases in both the deliberate (Experiment 1) and incidental (Experiments 1 and 2) learning groups.

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Musicians can easily read music symbols and Grégoire et al. (2013) pointed out that the Musical Stroop Effect can be explained by the automaticity of the learned association between the note position and note name. Musicians cannot avoid “naming” the note-position just as skilled readers cannot avoid reading color-words in the regular Stroop task. Furthermore, Schön et al. (2001, 2002) proposed that musicians rely on different types of translation when reading music. For instance, playing-like (i.e., visuomotor translation) and naming-like (visual-verbal translation) transcodings are important to automatize the process of sight reading. In general, sight reading seems to be a complex process based on visuomotor integration (Gudmundsdottir, 2010).

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In the present report, we showed that recently acquired associations, even if only learned incidentally, can produce the same automatic influences on behavior. Although our predictive stimulus (note-position) was not task-relevant (i.e., not the target stimulus), it produced an effect on performance, anyway. That is, our participants were able to learn the associations between note names and note positions as well as the corresponding actions. As mentioned in the Introduction, it may be the case that learning the contingencies between the

822 predictive stimulus and the target drives the prediction of the motor response. Further, it is
823 likely the case that learning is so rapid because participants can gain extensive practice of the
824 stimulus-response pairings in a short period of time, which often is not the case with more
825 deliberate learning procedures (Logan & Klapp, 1991). Although contingency learning has
826 been observed in numerous learning paradigms (e.g., the color-word contingency learning
827 paradigm), here we show for the first time the presence of the contingency effect in a music-
828 related task. We were able to prove that the same sort of learning observed between simple
829 stimulus pairs (e.g., colors and words) is also observable with more complex (e.g., in terms of
830 the number of stimuli presented and the number of associations to learn) and more ecological
831 musical materials.

832 The main aim of Experiment 2 was to investigate to which extent previous knowledge
833 can influence the contingency effect found in Experiment 1. We asked for nonmusician
834 participants who do not know how to sight read, though there is always a risk that
835 participants have studied music at school and remember more than they imagined. We
836 therefore scrambled the note-name to note-position correspondences. Reassuringly, a
837 contingency effect was still found in Experiment 2, suggesting once again a rapid incidental
838 learning of the presented associations. As the associations between note positions and
839 responses to the note names were *not* congruent in Experiment 2, this learning effect could
840 not have been due to preexisting sight-reading knowledge. However, in Experiment 2 a
841 congruency effect was also found, suggesting the presence of previous musical knowledge in
842 some participants, possibly due to music training at school. Based on this evidence, it is
843 possible that the contingency effect in Experiment 1 was influenced by the congruency effect
844 (i.e., because in Experiment 1, contingency was confounded with congruency, since all high-
845 contingency trials were congruent and all low-contingency trials incongruent). In any case,
846 our results, though indicating that undisclosed musical knowledge might impact the measure

847 of learning if only congruent associations are used, true contingency learning is still present
848 during the learning phase.

849 To further elucidate the congruency effect observed in Experiment 2, we ran a third
850 experiment in which we investigated the hypothesis that the congruency effect in Experiment
851 2 was influenced by the SMARC effect. As previously mentioned, the SMARC effect refers
852 to the natural human tendency for spatially coding pitches (Rusconi et al., 2006), even
853 without the presence of an actual sound (Ariga & Saito, 2019). Based on this premise, in
854 Experiment 3 we dissociated congruency from stimulus-response spatial compatibility. In this
855 way, we distinguished between congruent trials, in which the note name was congruent with
856 the note position (e.g., the note name “do” in the position for “do”) and compatible trials,
857 where the spatial position of the target was compatible to the spatial position of the response
858 key on the keyboard (e.g., the note name “do” in the bottommost “fa” note position when the
859 key responses were ordered from “do” to “si”). Our aim was to measure to which degree the
860 previously observed congruency effect was due to preexisting sight-reading knowledge (as
861 measured by congruency) and/or to a SMARC-like spatial compatibility effect. In response
862 times and errors, we failed to replicate the finding of Experiment 2, with no congruency or
863 compatibility effect. Potentially, this might indicate that the significant congruency effect in
864 Experiment 2 was due to Type 1 error, or that some other seemingly trivial difference
865 between Experiments 2 and 3 was responsible for the different outcomes. However, while in
866 our study participants were engaged in an incidental learning procedure, previous SMARC
867 studies (Ariga & Saito, 2019; Rusconi et al., 2006) asked participants for explicit judgements.
868 It is worth noting that in our study also, when nonmusicians were required to provide an
869 explicit response in the test phase, their performance was significantly above chance level,
870 suggesting the presence of a SMARC effect. We also observed above-chance congruent
871 responses in the same test phase, clearly indicating that some small number of participants

872 did have some preexisting knowledge. This suggests that future studies that aim for a “pure”
873 measure of learning might be best adapted with some form of pretest of preexisting
874 knowledge and/or non-spatially compatible stimulus-response mappings.

875 Additionally, as previously hypothesized, overall test phase accuracy (objective
876 awareness), in both Experiments 1 and 2, indicates that nonmusicians performed above
877 chance, suggesting that they were able to learn the associations that they were exposed to and
878 even to verbalize this knowledge. However, in Experiment 1, a significant difference in favor
879 of the deliberate learning group in the objective awareness results suggests that deliberate
880 learning boosts learning more than purely incidental learning does. Previous research showed
881 that to learn contingencies, being attentive to the predictive dimension is important (Eitam et
882 al., 2009; Jiang & Chun, 2001). If this is the case for the deliberate learning group, then it is
883 not surprising that they gave more accurate responses in the objective awareness phase than
884 the incidental learning group did. At the same time, the evidence in favor of the deliberate
885 learning group may simply suggest that learning in a deliberate way might aid more during
886 explicit reporting (in the objective awareness phase) than in the case of automatic execution
887 (in the learning phase). In other words, our objective awareness phase specifically required
888 participants to express an explicit judgment, unlike the learning phase where participants
889 were asked for automatic execution. Although, the deliberate learning group reported more
890 accurate response in the objective awareness phase than the incidental one, the nonsignificant
891 Contingency \times Group interaction in the learning phase suggests that the two groups were able
892 to automatize the learned contingencies in a quite similar way. Thus, deliberate learning may
893 provide an advantage when it comes to explicit reporting, but perhaps may not confer the
894 same advantage for automatization of contingency knowledge.

895 Although the observed acquisition of sight-reading knowledge may seem implausibly
896 fast to some readers, such results are not a surprise when considering prior contingency

897 learning work with other stimuli. As previously mentioned in the Introduction, contingency
898 learning paradigms like the present one allow for extremely rapid acquisition of the
899 associations between stimuli in a task (Lin & MacLeod, 2018; Schmidt et al., 2010; Schmidt
900 & De Houwer, 2016), therefore the present results are completely coherent with past work
901 using related, nonmusical learning procedures.

902 We note that our aim was not to claim that a procedure such as ours can replace other
903 types of deliberate practice, which are more goal-oriented (Ericsson et al., 1993; Ericsson &
904 Harwell, 2019; Mishra, 2014). On the contrary, we believe that the acquisition of complex
905 skills, such as sight reading, can benefit from both deliberate and incidental learning
906 procedures. On one side, more deliberate training can guide the acquisition of instrument-
907 specific skills, such as effortful strategies to improve the technical movements of the bow on
908 the strings to play the violin. On the other hand, an incidental learning procedure such as that
909 used in the present report can help with the automatization of visuomotor integration,
910 favoring sight-reading performance.

911 As one potential limitation, in the current study participants responded to note-names
912 and learned about the note-positions incidentally. We did this for a few reasons. Most
913 importantly, the current methodology allowed us to study the automatic (i.e., stimulus-driven)
914 influences of note-position knowledge on performance (e.g., akin to the musical Stroop with
915 experienced musicians or the influence of color words on color naming in the traditional
916 Stroop paradigm). Learning may, however, be even stronger and faster if participants respond
917 to the note positions directly (i.e., the note-position is the target, rather than the task-
918 irrelevant but informative stimulus). We are currently investigating this in an ongoing study.
919 Furthermore, as already noted in the Introduction, we used an imperfect contingency
920 manipulation (75% high contingency vs. 25% low contingency). Although this was done to
921 measure learning while it was occurring, a perfect contingency manipulation (e.g., using a

922 100% congruency between note-names and note-positions) may further help learning,
923 especially in a real-world application (e.g., helping nonmusicians to acquire sight-reading
924 skills with a learning app). This point is the object of another ongoing study we are currently
925 conducting.

926 As another limitation, although we used arbitrary stimulus-key assignments similar to
927 the ones that musicians practice on their instrument (especially piano), we did not use real
928 instruments for learning. In future research, using the same logic of this study, it may be
929 interesting to use a very similar piano response modality, or also other types of instruments
930 (like string or wind instruments). A vocal response modality (e.g., singing) could also be
931 used. Globally, the goal was to show that this type of position-to-action learning can occur
932 rapidly with an appropriately designed learning procedure, but real-world applications to
933 actual instruments remains to be explored. Furthermore, although here we mostly focused on
934 the acquisition and automatization of the associations between spatial positions and motoric
935 responses, previous research suggested that auditory stimuli are important to train sight-
936 reading skills. That is, sight reading benefits greatly from an integration of visual, auditory,
937 and motor components (Brodsky et al., 2003, 2008; Gromko, 2004; Hayward & Eastlund
938 Gromko, 2009), rather than just visuomotor integration (Gudmundsdottir, 2010). In other
939 words, learning what the note positions sound like can facilitate sight-reading skills. In on-
940 going studies, we are investigating the role of auditory stimuli in learning in our task, to
941 further test the facilitative benefit of auditory stimuli in the acquisition of sight-reading skills.

942 In conclusion, we showed the presence of the contingency effect in an incidental
943 music contingency procedure, as well as the ability to verbalize the knowledge that was
944 incidentally (or deliberately) acquired. Such findings are exciting, because they suggest that a
945 seemingly difficult-to-learn music skill, sight-reading, can be learned much more quickly and
946 easily than previously assumed. In the short-term, we hope that this paper will serve as the

947 starting point for further investigations of the incidental learning of complex material,
948 musical or otherwise, including investigations of ways to reinforce learning even further. In
949 the long-term, this study may open up a new line of research to implement the same or
950 similar approaches in an applied setting to help novices (whether in a musical and nonmusical
951 context) to acquire valued skills with greater ease.
952

953 **Declaration of Conflicting Interests**

954 The Authors declare that there is no conflict of interest

955

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959

960 **Ethics Statement**

961 In accordance with the local legislation and institutional requirements, ethical review and

962 approval for research on human participants in cognitive psychology study was not required.

963

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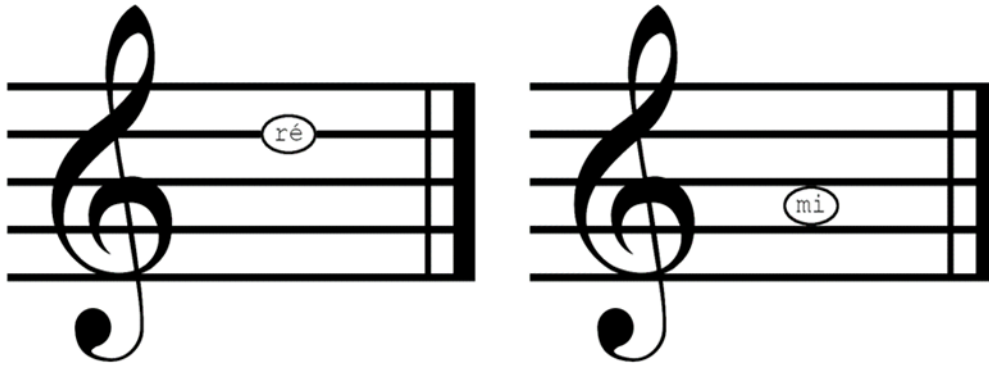
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Figures

Figure 1

Example stimuli in the musical contingency task.



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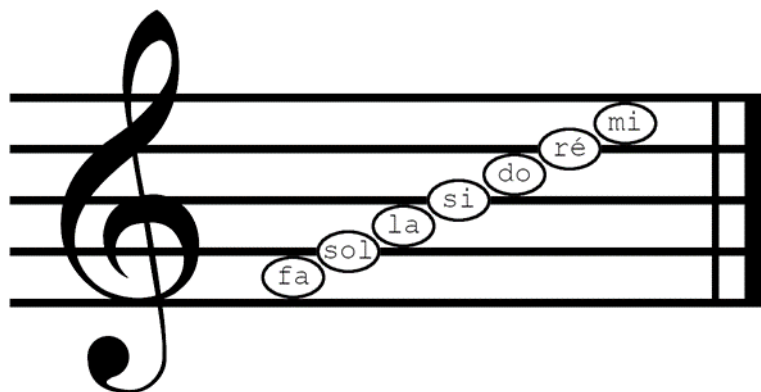
Note. On the left, a congruent stimulus (“ré” printed in the note for ré).
On the right, an incongruent stimulus (“mi” printed in the note for la).

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Figure 2

Full range of note positions used in the experiment, with congruent names.

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Note. An individual note was horizontally centered on a smaller staff in the actual experiment, as in Figure 1.

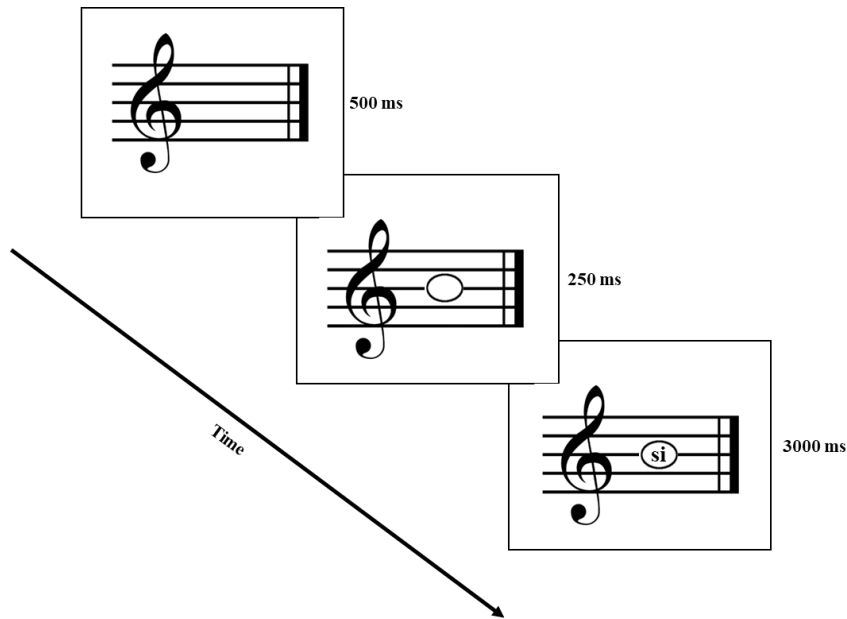
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Figure 3

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Order of stimuli appearance during the learning phase.

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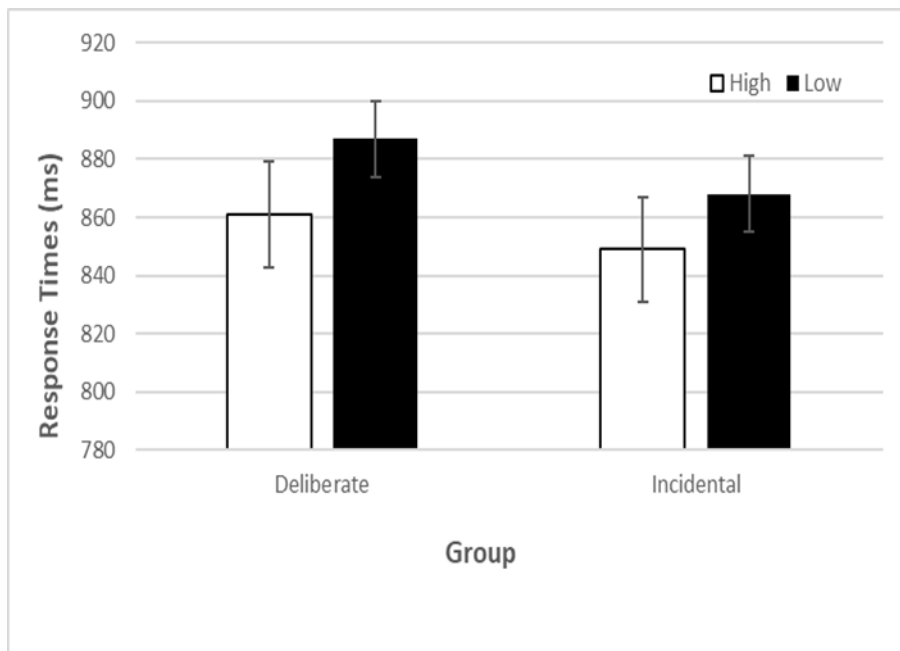
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Figure 4

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Experiment 1 RTs for deliberate and incidental groups.

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Note. Interaction between Contingency (High and Low) and Group (Deliberate and Incidental), standard error bars are shown in the figure.

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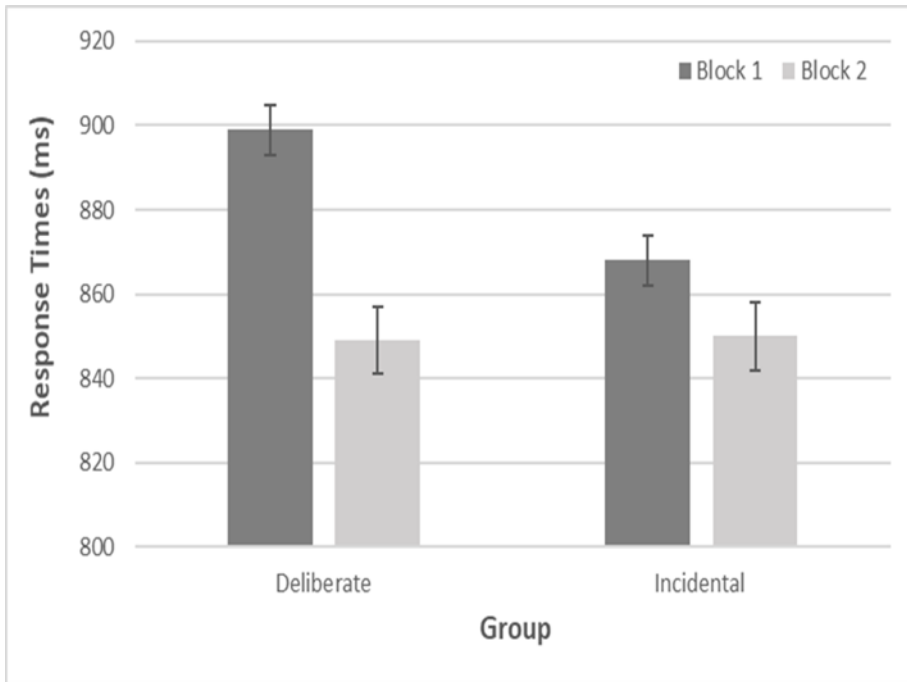
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Figure 5

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Experiment 1, interaction between Block and Group.



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Note. Averaged response times across high and low contingency trials for block (Block 1 and Block 2) for the deliberate and incidental learning groups (standard error bars are shown).

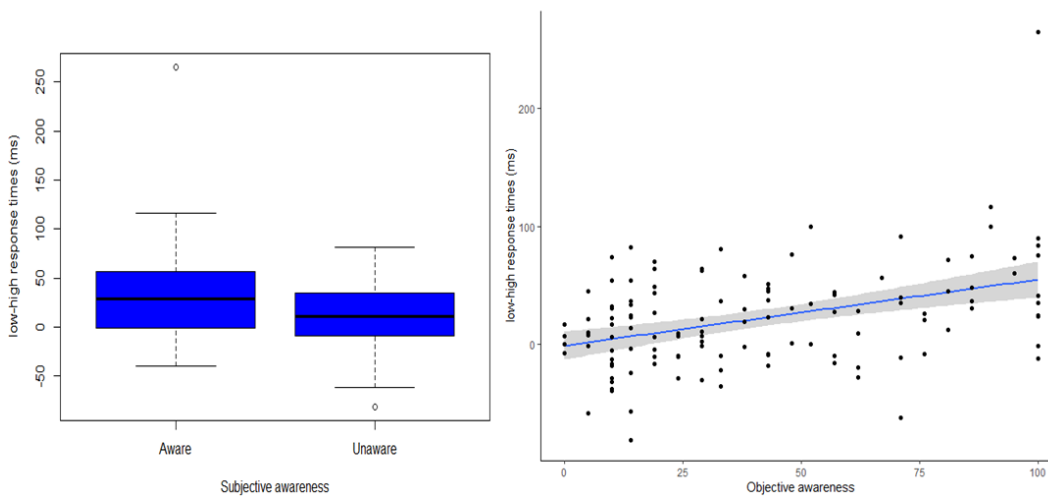
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Figure 6

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Experiment 1, correlations between contingency effect and subjective and objective awareness.



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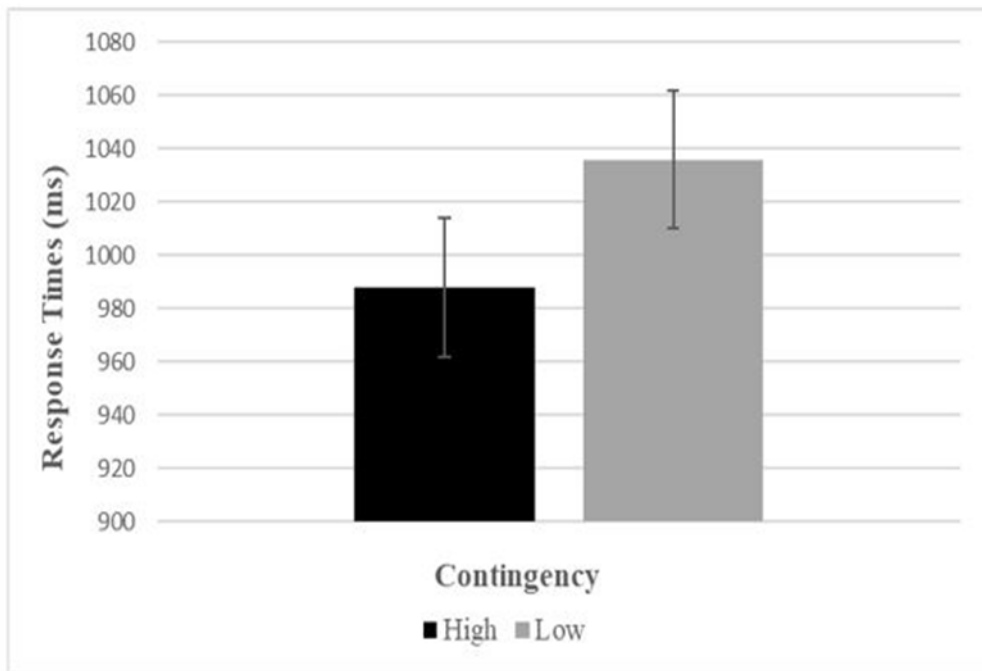
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Note. In the left panel, the correlation between the contingency effect and subjective awareness is shown. In the right panel, the correlation between the contingency effect and objective awareness (test phase) is shown.

1301 **Figure 7**

1302 *Experiment 2, averaged mean for Contingency effect.*

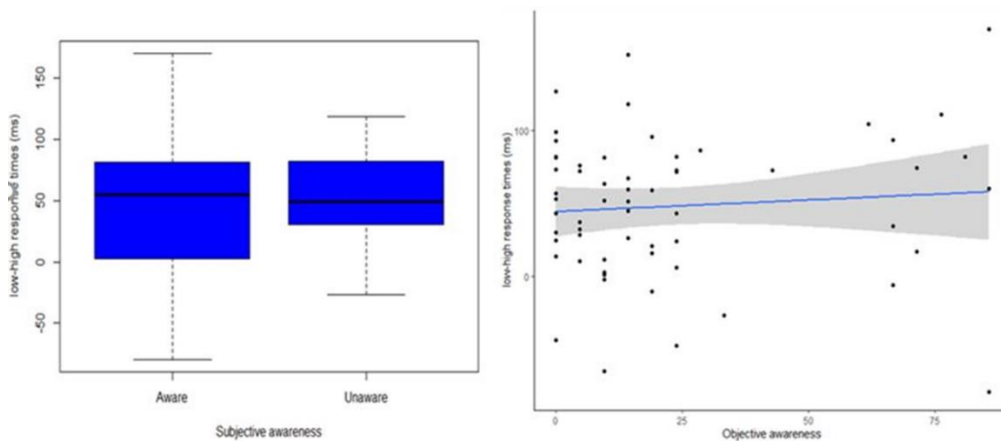


1303 Note. Averaged mean scores between groups for high- and low-contingency
 1304 trials. Error bars represent standard errors.

1305

1306 **Figure 8**

1307 *Experiment 2, correlations between contingency effect and subjective and objective awareness.*



1308 Note. In the left panel, the correlation between the contingency effect and subjective awareness
 1309 is shown. In the right panel, the correlation between the contingency effect and objective
 1310 awareness (test phase) is shown.

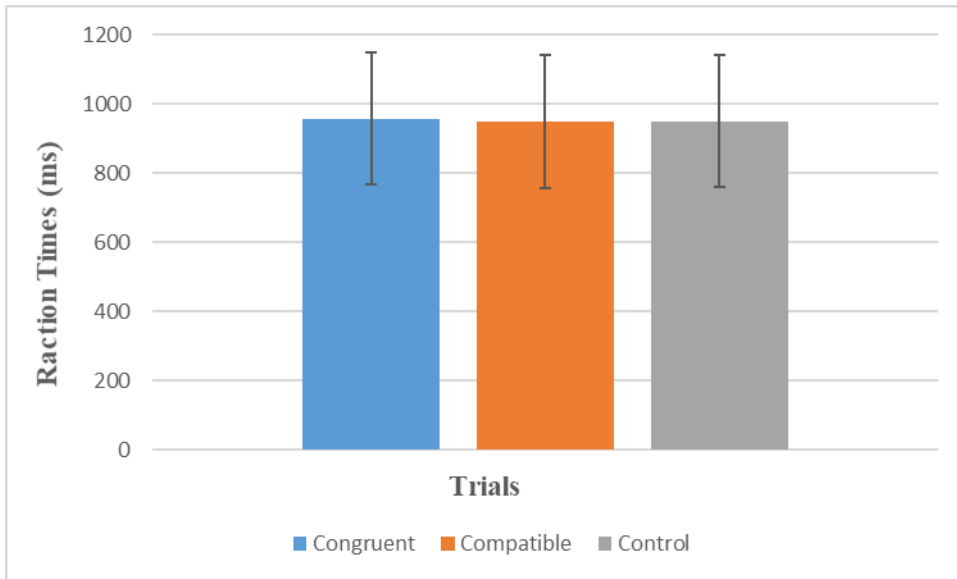
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Figure 9

Experiment 3, RTs for the different trials.



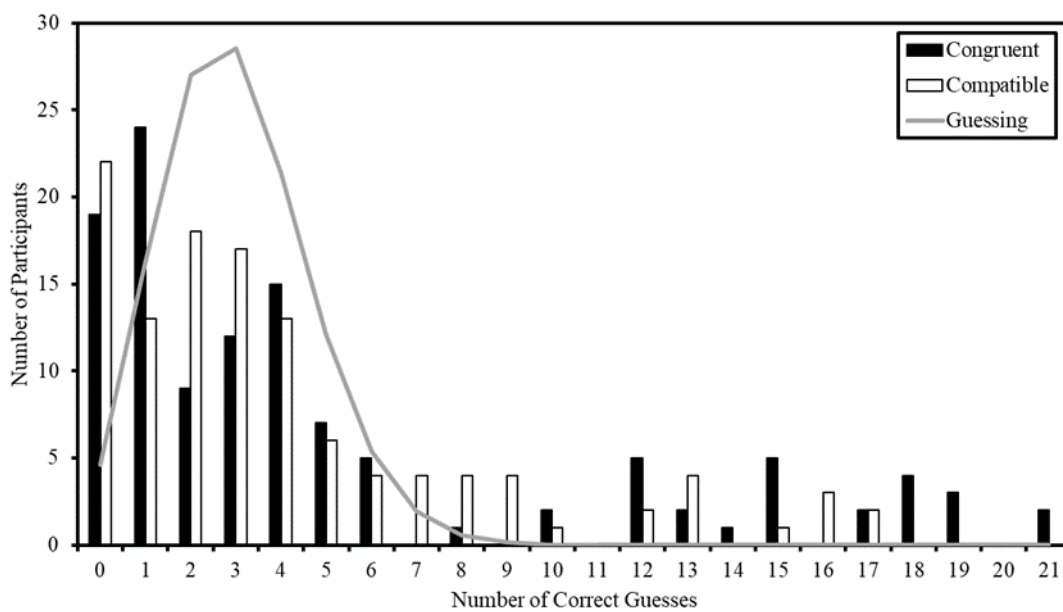
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Note. Mean RTs scores for the different trials: congruent, compatible and control.

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Figure 10

Experiment 3, distributions of the number of congruent and compatible guesses (out of 21) along with the expected number of correct responses if guessing alone.



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Note. The guessing curve assumes that participants do not have a bias to repeat the same response to the same stimulus. The distribution would be flatter if participants have said bias, probably explaining the larger number of participants with a score near zero and multiples of three along with the smaller number of participants near the expected peak of the distribution.

1325

1326

Table 1

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1328

Experiment 3, Musical Stroop contingency learning manipulation.

Note Name	Note position						
	Do	Ré	Mi	Fa	Sol	La	Si
Do	3	3	3	<u>3</u>	3	3	3
Ré	3	3	3	3	<u>3</u>	3	3
Mi	3	3	3	3	3	<u>3</u>	3
Fa	3	3	3	3	3	3	<u>3</u>
Sol	<u>3</u>	3	3	3	3	3	3
La	3	<u>3</u>	3	3	3	3	3
Si	3	3	<u>3</u>	3	3	3	3

1329

Note. Numbers of repetition for each trial. Congruent trials in **bold**, compatible trials in *underlining italic* and control trials in standard font.

1330