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A novel Tactile Braille-Stroop test (TBSt)

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Abstract
Stroop interference effects occur when word reading and the target words' print color naming are incongruent. This interference reflects reading proficiency while naming print color instead of reading color's names. We devised a tactile version of the Stroop test in which the congruity between three target materials (paper, Braillon, and plastic) and the embossed materials' names, in braille, was manipulated. The participants' task was to palpate and name the target materials. The baseline condition was a board with 63 cells each containing one of the target materials. Three similarly constructed boards had (a) a single non-sensical triplet of braille letters embossed on all stimuli, and (b) the first three consonants of the material's name, embossed in braille, congruently, or (c) incongruently. A total of 45 blind participants were tested: young adults, high school, and elementary school students (16, 10, and 3 mean years of braille reading, respectively). Older, more experienced braille readers showed the largest Stroop interference costs, in speed and accuracy, not only in the incongruent condition but also in the non-sense (non-word) condition compared to the congruent condition. Also, the adults committed more errors compared to high school students in the incongruent condition. However, the more experienced braille readers were faster in the congruent condition compared to the non-word condition. Elementary school children showed no relative gains in the congruent versus non-word condition, and only small incongruence (interference) costs in speed or accuracy. These findings indicate that braille reading competes with tactile material naming, as a function of reading proficiency, even for non-sensical letter strings, a Stroop effect.

Keywords
Stroop test, Tactile discrimination, Braille reading, Automaticity.

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Introduction

In the landmark studies of J. R. Stroop, participants were tested on naming the ink color of color name words, aloud, when the two aspects of the stimuli were incongruent, compared to the naming of colored patches or artificial letter-like shapes (MacLeod, 1991; Stroop, 1935). Interference ("Stroop" costs) in the former condition was reflected in the difference between the color naming times, that is, slower color naming in the incongruent color words condition (Stroop, 1935). Automaticity, here, refers to the highest level of proficiency in the process of reading, with minimal cognitive efforts.

In the standard Color–Word Stroop Test (CWST), one is asked to name the ink color of color words under conditions wherein word meanings (indicating color names) and the ink colors are incongruent (e.g., the word *red* printed in green ink) (Uttl & Graf, 1997). The typical finding is that compared to their performance in a baseline condition of naming the colors of neutral stimuli (e.g., strings of X's), more experienced readers show slower naming times and/or commit more errors in the naming of the ink colors than do younger, less experienced readers (Cohn, Dustman, & Bradford, 1984; Houx, Jolles, & Vreeling, 1993; Kieley & Hartley, 1997; West & Alain, 2000). However, there are some indications that factors such as aging may affect Stroop costs in addition to the level of automaticity in reading (Vakil, Manovich, Ramati, & Blachstein, 1996; Verhaeghen & De Meersman, 1998).

Stroop effects have also been shown in the auditory modality (e.g., Hamers, 1973). In this version, participants have to indicate, verbally, the pitch (higher or lower) of heard target words (the words "low" or "high") presented either congruently or incongruently. In the non-congruent condition, the participants were asked to respond (verbally) while disregarding the verbal meaning of the presented auditory stimuli. The findings indicated a strong auditory Stroop effect with a significantly longer response time in the non-congruent condition compared to the congruent condition (Hamers, 1973). Note that the test does not include a neutral, baseline condition in which speed scores of responses can be compared to as a control condition (Dyer, 1973). Interference effects in this auditory Stroop task may be bidirectional (Shor, 1975), word-meaning on pitch, and vice-versa, but the effects are not dependent on the response modality (verbal, button press) (McClain, 1983). In a different, cross-modal version of the auditory Stroop task, Zakay and Glicksohn (1985) reported incongruity costs for musical notes and printed (visually presented) notes in professional musicians. Although the analogy to the word-color Stroop effects has been debated, it is clear that the note-reading-related costs are dependent on the level of musical literacy (MacLeod, 1991).

Literacy skills can be acquired also via the tactual modality, specifically, braille reading which is considered as the primary reading modality in legally blind individuals, especially young students either with congenital blindness or with a progressive visual impairment that is expected to cause significant deterioration of vision with time.

The braille code is a standardized, reading–writing system that is based on the basic braille cell; a tactual configuration of up to six raised, embossed dots organized in a standard matrix of 2×3 possible dot locations. Various combinations of dots, and corresponding dot-less spaces in the matrix, represent alphabetical letters (consonants, vowel) as well as numerals and punctuation marks or abbreviations, prefixes, and suffixes. Braille reading is based on successive fine tactual discriminations of different strings of braille cells arranged in rows, using one or both index fingers. Braille letters are printed from left to right in all languages, including Arabic and Hebrew. There is good support for the notion that braille letter discrimination can be considered as a perceptual or perceptual motor skill (Jarjoura, 2012; Millar, 1997) and as such, braille reading would be subject to the advantages and constraints imposed on learning to read in other sensory modalities.

Table 1. Braille reading years and braille reading rates in the three age-groups.

Age-groups	Mean ± *SD* of braille reading years	Number of words per minute in braille
Adults (*n* = 22)	16 ± 4.2	32 ± 13
High school (*n* = 13)	10 ± 1.8	22 ± 6
Elementary (*n* = 10)	3.0 ± 1.5	16 ± 9

SD: standard deviation.

Here, we report significant Stroop effects in the tactual modality (i.e., Braille) and show that interference effects were correlated with braille reading experience and proficiency. The working hypothesis underlying the experiment was that there will be significantly larger Stroop costs (more interference) in blind high school and university students compared to young blind primary school children, reflecting an increased automaticity in braille reading.

Method

Participants

The participants were blind braille readers of Arabic as their native language. The study was approved by the Human Experimentation Ethics Committee (Institutional Review Board [IRB]) of the University of Haifa (Permit no. 014/08). Participants were recruited through letters distributed to parents of young blind students in local schools and by sending printed braille letters to all registered blind students at the University of Haifa. Informed consents were obtained from parents and adult participants.

The participants were recruited according to the following criteria: (a) recognized as legally blind by Israeli law, either diagnosed with congenital blindness or having severe visual impairment with visual acuity of less than 3/60 and less than a 20° visual field in the better eye; (b) native speakers of Arabic; (c) no significant language deficits or speech problems based on the evaluations of qualified speech therapists; (d) no physical lesions or sensory disruption in the dermatomes of the wrists, fingers, or fingertips, based on the occupational therapy and physical therapy evaluations; and (e) no other significant medical conditions and no history of a developmental delay according to medical reports, and specifically, no psychiatric or behavioral disorders.

Table 1 presents the mean number of braille reading years of the three groups of participants, as an indication of reading experience, and the group average number of words read aloud in a braille reading proficiency test comprising a list of 18 high-frequency Arabic words transcribed as non-vowelized braille words, consisting of 110 braille characters (Jarjoura, 2012).

Vowelization in Arabic alphabet refers to a set of phonemic diacritics, written above or under each letter, in order to support spelling and word recognition (Saiegh-Haddad & Henkin-Roitfarb, 2014). The list reading times were converted into words-per-minute scores.

Reading rates increased with age. A Pearson test revealed a positive significant correlation ($r = .69$; $p < .001$) between braille reading experience, as expressed in total number of reading years, and the braille reading rate of a list of 18 unvowelized words in Arabic.

Stimuli and apparatus

A tactual Stroop task was developed for this study. Four metal boards, 20 cm × 25 cm each, were used to mount and present the stimuli, one for each of the task conditions. On each tactile Braille-Stroop

Figure 1. The experimental apparatus: The "Start" button, in black on the left, and the Stroop board on which triplets of braille letters were embossed congruently with the materials.

board, 63 square (2 cm × 2 cm) pieces of three different types of smooth solid materials (texture-stimuli) were arranged: paper (21 stimuli), transparent plastic (21 stimuli), and Braillon (21 stimuli of a plastic-like paper developed specifically for long-lasting braille printing). The materials in each of the three groups, consisting of 21 stimuli, were pseudo-randomly arranged (attached) in seven rows, with eight texture-stimuli in each row, except the last row that had seven stimuli; adjacent pieces always were of different materials, and each row had at least one piece of each of the materials. The number of 63 pieces was chosen because we were convinced that a lesser number of tactile stimuli may not reflect Stroop costs, whereas a larger number of tactile stimuli may lead to inattention and cause fatigue, especially in the group of young participants.

In the *baseline* tactile board (condition), the stimuli had their original natural surfaces, that is, there were no braille letters or any embossed patterns. In the *congruent* tactile Braille-Stroop board (Figure 1), each tactile stimulus had one of three possible braille letter strings embossed on its surface. The letter strings were the first three consonants of the words "paper," "plastic," or "Braillon" (e.g., the string "brl" for Braillon, in unvowelized Arabic braille), and there was a strict congruity between the material and the braille letter string indicating its name.

The word trimming procedure, used to shorten the words, was based on Arabic script without short vowels that is introduced during the later years of primary school. This approach was based on a study, in English, that found a significant interference effect in the (visual) CWST when using the first three letters of each color (McCown & Arnoult, 1981). In the *incongruent* tactile Braille-Stroop board, the letter strings (the first three consonants of the words "paper," "plastic," or "Braillon") were always incongruent with the material on which they were embossed. The fourth tactile Braille-Stroop board, the *non-word* board, had a non-sense triplet of identical braille letters (e.g., www and rrr) embossed on the surface of each tactile stimulus in a random manner; the same material could have a different braille letter triplet embossed on it in each piece (tactile stimulus).

A custom-made apparatus was designed for running the Stroop experiments. The apparatus included a wooden holder board to anchor the Braille-Stroop boards with the tactile stimuli as well as a "start" button and a "stop" button. The "start" button was positioned to the left of the top line of the stimuli, and the "stop" button was positioned to the right of the lowest line of the stimuli, immediately after the final tactile stimulus. The response buttons were connected to a computer by a USB data cable. A dedicated software package was written and developed for running the experiment and for response timing. In addition, the participants' verbal responses were recorded by a commercial digital audio microphone and a video camera.

Tactile Braille-Stroop task procedure

The four conditions (*baseline, congruent, incongruent*, and *non-word*) were presented by the same experimenter to all participants with verbal instructions to release the "start" button (start position) when ready, and successively palpate the different stimuli using the right index finger, moving from the left upper corner and ending in the right lower corner of the board. Participants were instructed to immediately press when reaching the "end" button. The participants were asked to *name* the different textures (both flat and embossed) disregarding the embossed braille letters/words printed on the different textures, as fast as possible. On releasing the "start" button, a digital time measurement was initiated by the software program, and this measurement continued until palpation of the 63 stimuli was completed and the "stop" button was pressed. Total time for each board was presented on the computer's screen but was visible only by the experimenter. The accuracy of verbal responses, in each Stroop condition/board, was digitally recorded for offline analysis.

Measurements

The total time to recognize all 63 tactile items (*in seconds*) was measured in the four tactile Stroop boards (conditions): *baseline, congruent, incongruent*, and *non-word*. Additionally, accuracy in each tactile Stroop condition was assessed by the absolute number of incorrect verbal responses (incorrect naming of the tactile item, target texture).

Stroop costs in speed were calculated by subtracting the baseline recognition time from each participant's tactile recognition times in the congruent, incongruent, and non-word conditions. In addition, to directly assess the speed costs of incongruity, the performance times in the *incongruent* condition were compared to the performance times in the *congruent* condition (normalized to each individual's performance speed in the baseline condition). Because participants made only a few, occasional, errors in the baseline condition, Stroop costs in accuracy were calculated, for each participant, by subtracting the number of errors in the non-word condition from the errors committed in the congruent and incongruent conditions.

Results

Performance speed

Total tactile task performance times (per board/condition) were digitally scored for each participant, and then the mean group tactile recognition time was calculated for each of the three age-groups in order to assess between-group differences. Table 2 presents the tactile recognition time (in seconds ± standard deviations [*SDs*]) in the three tactile Stroop conditions and in the *baseline* tactile discrimination condition in the three age-groups.

Participants of all three age-groups (adults, high school, and elementary school) achieved their fastest tactile performance time in the baseline tactile condition (i.e., while discriminating textures with no embossed braille letters). Tactile performance times were longest in the *incongruent* condition. A repeated measures (RM) analysis of variance (ANOVA), with a model of three *age-groups* as the between-subject factor and four *Stroop conditions* as a within-subject factor, showed significant between-condition differences ($F(3, 42) = 114.25$; $p < .001$). There was also a significant *group* effect ($F(2, 42) = 17.6$; $p < .001$). Scheffe tests revealed that the adults, as well as the high school students, achieved significantly faster performance times in all conditions compared to the elementary school children. There was no significant *age-group* × *Stroop condition* interaction ($F(6, 80) = 1.67$; $p = .54$)

Table 2. Mean performance time (in seconds ± *SDs*) in the four Stroop conditions in the three age-groups of blind participants.

Groups	Stroop conditions			
	Baseline	Incongruent	Congruent	Non-word
Adults (n = 22)	83 ± 23	178 ± 58	134 ± 44	158 ± 51
High school (n = 13)	95 ± 26	214 ± 66	166 ± 47	185 ± 56
Elementary (n = 10)	161 ± 39	285 ± 73	257 ± 64	255 ± 70

SD: standard deviation.

indicating that in all three age-groups, there was a similar relationship between the time required to perform the task in each of the different Stroop conditions.

Performance speed costs

Table 3 presents the costs in performance speed in the *incongruent, congruent*, and *non-word* conditions relative to performance times in the *baseline* tactile condition in the three age-groups. The presence of braille letters resulted in a slowing of material discrimination times irrespective of whether the string was meaningful or not. In both the adults and the high school students, the smallest costs were found in the *congruent* condition. Compared to the *congruent* condition, the costs in the *non-word* condition were on average 47% and 27% larger, in the adults and high school students, respectively. However, the elementary school children had similar costs in the *congruent* and in the *non-word* condition. The adults and high school students showed speed gains (i.e., negative costs) in the *congruent* condition compared to the *non-word* condition.

The largest Stroop costs in speed occurred in the *incongruent* condition but with a clear age-group (literacy history) effect; on average, there were 86%, 68%, and 29% larger costs (compared to *congruent*) in the adults, high school students, and the elementary school children, respectively. Thus, the adults showed not only the smallest absolute costs in the *congruent* (compared to baseline) condition but also the larger relative benefits compared to the *incongruent* and *non-word* conditions.

A one-way ANOVA with *age-group* as a between-subject factor and performance times in the *incongruent* condition compared to the performance times in the *congruent* condition (normalized to each individual's performance speed in the *baseline* condition) showed a significant age-group effect ($F(2, 42) = 3.72$; $p = .03$). Post hoc (Scheffe) comparisons between groups showed that the costs of incongruity were significantly larger in the adults compared to the elementary school children ($p = .04$); there was also a trend toward a difference in costs between the high school and the elementary school students ($p = .09$), the latter showing the smaller costs.

In summary, in all three age-groups, there were significant Stroop costs (interference) in speed in all three conditions compared to the baseline tactile discrimination speed. These costs were most pronounced in the *incongruent* condition. The adults, however, had the largest Stroop costs (interference) in speed in the *incongruent* condition compared to the *congruent* condition.

Performance accuracy

Table 4 presents the group average number of errors committed in the four task conditions by the participants of the three age-groups. The accuracy scores of two participants (one adult and one elementary school student) were excluded from the statistical analyses because the number of tactile errors these individuals committed was more than two *SDs* of their respective group means in

Table 3. Costs in performance speed (in seconds) in comparison with the baseline performance times, in the three braille conditions in the three age-groups of blind participants.

Groups	Stroop conditions		
	Incongruent	Congruent	Non-word
Adults (*n* = 22)	+95	+51	+75
High school (*n* = 13)	+119	+71	+90
Elementary (*n* = 10)	+124	+96	+94

Table 4. Number of tactile discrimination errors in the baseline and three Stroop conditions in the three age-groups of the blind participants.

Groups	Stroop conditions			
	Baseline	Incongruent	Congruent	Non-word
	Mean ± *SD*	Mean ± *SD*	Mean ± *SD*	Mean ± *SD*
Adults (*n* = 21)	1 ± 1.4	17 ± 7.5	11 ± 9.7	17 ± 8.6
High school (*n* = 13)	1 ± 1.6	16 ± 7.2	13 ± 9	15 ± 8.8
Elementary (*n* = 9)	3 ± 2.3	18 ± 5.5	18 ± 10.3	19 ± 12.2

SD: standard deviation.

more than a single Stroop condition. All of the participants achieved near ceiling tactile discrimination accuracy in the *baseline* condition.

An RM-ANOVA with *age-group* as a between-subject factor and the number of errors in the four *Stroop conditions* as a within-subject factor showed a significant difference between conditions in tactile discrimination accuracy ($F(3, 42) = 68.87$; $p < .001$). There was, however, no significant age-group effect ($F(2, 42) = 1.0$; $p = .43$) and no significant age-group × condition interaction ($F(2, 40) = 0.3$; $p = .3$). In all three age-groups, participants tended to commit tactile discrimination errors when braille letters were embossed on the background textures. Nevertheless, fewer errors were committed in the *congruent* condition in the two older participant groups.

Because only a few, if any, errors were committed in the baseline tactile discrimination condition, the Stroop costs in accuracy in the *congruent* and *incongruent* conditions were computed and also compared to the *non-word* condition (Table 5). Both the adults and the high school students had small relative gains in accuracy in the *congruent* condition while showing only minimal relative costs in the *incongruent* condition. The elementary school children showed no relative advantage in the *congruent* condition in terms of tactile error scores, compared to the *incongruent* condition. An RM-ANOVA with *age-group* as a between-subject factor and the Stroop costs in errors compared to the *non-word* condition as a within-subject factor showed a significant difference between the *congruent* and *incongruent* conditions in tactile discrimination accuracy ($F(1, 42) = 5.9$; $p < .05$). There was, however, no significant group effect ($F(1, 42) = 0.45$; $p = .64$) nor a significant *age-group* × *Stroop-cost-condition* interaction ($F(1, 40) = 2.2$; $p = .13$).

Discussion

This study investigated the costs in speed and accuracy that braille readers of different reading proficiency levels may face due to the incongruity between tactile textures to be recognized (target materials) and the braille letters referring to the target textures' names embossed over the target

Table 5. Tactile discrimination costs in accuracy (number of errors committed) relative to the non-word condition in the three age-groups.

Groups	Stroop conditions	
	Congruent	Incongruent
	Mean ± *SD*	Mean ± *SD*
Adults (*n* = 21)	−5.7 ± 8.4	0.5 ± 3.9
High school (*n* = 13)	−2.5 ± 5.4	0.6 ± 4.5
Elementary (*n* = 9)	−1.5 ± 4.3	−1.6 ± 10.2

SD: standard deviation.

material. It was hypothesized that as in the standard visual Stroop test, there will be significantly larger Stroop costs (less interference) due to the incongruity, with increasing proficiency in braille reading.

The results showed that in all three age-groups, tactile discrimination speed was the slowest in the *incongruent* condition and, relative to the *baseline* condition, tended to show the smallest costs in the *congruent* condition. There was a significant group effect with absolute discrimination times tending to be smaller in the older, more proficient braille readers compared to the elementary school children. Moreover, comparisons of the Stroop costs in speed, relative to the *baseline* condition, showed that in both the adults and the high school students, the smallest costs were found in the *congruent* condition. The adult, more proficient readers showed on average not only the smallest absolute costs in the *congruent* (compared to *baseline*) condition but also the larger relative benefits compared to the *incongruent* and *non-word* conditions. However, because of large between-individuals differences in tactile discrimination performance, and the relatively small number of elementary and high school participants, there was no significant age-group and test-condition interaction when absolute discrimination times were compared.

All three age-groups showed costs in discrimination time (relative to baseline) even in the *non-word* condition, indicating that the presence of braille letters makes a difference in tactile texture discrimination even when the letters lacked semantic content. The speed costs in the *non-word* condition were on average 47% and 27% larger, compared to the *congruent* condition, in the adults and high school students, respectively. However, the elementary school children had on average similar costs in the *congruent* and in the *non-word* condition, suggesting that even in readers with the lowest levels of proficiency, wherein palpating congruent letter strings lead to no advantage compared to non-sense strings, the presence of meaningful incongruent letter strings resulted in significant tactile discrimination costs. Thus, even relatively low-proficiency readers of braille found it difficult to disregard meaningful print patterns.

A similar general pattern of results was reflected in the error rates. While participants from all three age-groups tended to be highly accurate in tactile discrimination in the *baseline* condition (i.e., when no braille letters were embossed), relative Stroop costs were apparent in the error scores in all three conditions with the braille-embossed targets. On average, the adults committed about 55% more errors in tactile discrimination in the *incongruent* condition compared to the *congruent* condition, while the high school students committed, on average, 23% more tactile errors. Moreover, overall, the costs in accuracy were significantly smaller in the *congruent* than in the *incongruent* condition when compared to the *non-word* condition. Although group differences were not significant, the relative benefits of the *congruent* condition were more clearly apparent in the adults; there was overall a small benefit of congruency even in comparison with the *non-word* condition. The elementary school children committed on average the same number of tactile discrimination errors, in the *incongruent* and the *congruent* conditions.

Altogether, the current results indicate that while tactile discrimination skills seem to improve with age and experience in blind individuals, the relative costs of text–texture incongruence become larger. This pattern of increasing costs in encountering letter strings (especially incongruent ones) with increasing tactile discrimination abilities is compatible with the notion of an increasing difficulty in disregarding print in the tactile domain with increasing text exposure and braille reading proficiency. Thus, increasing experience in braille reading of different age-groups tends to increase the relative tactile Stroop costs in the *incongruent* condition indicating that the suppression of braille reading (as a well-established skill) in older, more braille-literate individuals becomes more difficult. The current results therefore parallel the findings in the standard Stroop test in the visual domain (Cohn et al., 1984; Houx et al., 1993; Kieley & Hartley, 1997; West & Alain, 2000).

The Stroop costs in the *non-sense* condition (speed and accuracy) in both high school students and adults were on average larger than those incurred in the *congruent* condition. However, speed costs, in both these groups, were smaller in the *non-sense* condition compared to the costs in the *incongruent* condition. Both these results indicate that braille letter strings are processed and decoded to a level that presumably represents their meaning rather than simply adding a level of difficulty to tactile texture discrimination. Thus, the tactile Stroop seems to reflect a primacy, "automaticity," of reading in the tactile domain, in similarity to the automaticity of reading proposed to be reflected in the Stroop costs in the visual domain (MacLeod, 1991).

Previous studies (Davidson, Zacks, & Williams, 2003; Dulaney & Rogers, 1994; MacLeod, 1998) showed similar results in relation to the CWST, that is, the older, more proficient readers were relatively slower, and less accurate, than younger, less proficient readers in responding (color naming) in the *incongruent* condition compared to the *congruent* condition. Thus, the current results are in line with the notion that the suppression of an irrelevant percept (i.e., lexical recall) may become more difficult with the establishment of a perceptual skill that specifically increases the saliency of that percept, especially when a less well-trained feature of the stimuli is volitionally targeted (MacLeod, 1991).

The major results of this study indicate that the Stroop effects are not modality specific and, as such, can be evoked in the tactile modality under similar rules that apply to the visual and auditory ones. The tactile version of the Stroop test described in this study, as considered a new testing device, should be further validated in other age-groups and other languages and would be of a special interest in studying and assessing blind individuals with developmental and acquired learning disabilities and language impairments. Specific effort in this context may be also directed to study tactile Stroop costs in larger groups of participants with different levels of visual impairments and residual vision as means to assess braille reading automaticity. Importantly, given that the Stroop costs reflect reading skill, the Tactile Braille-Stroop test (TBSt) has the potential to be developed as an independent measure to compare different braille teaching methods. In addition, the tactile Braille-Stroop – as a research tool – has the potential to be implemented as a tool to study and test tactile memory and executive functions in braille readers in parallel with accepted uses of the standard Stroop test in the visual modality (Phillips, Bull, Adams, & Fraser, 2002; Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006). The TBSt may be also used to compare the efficacy of many different "substrates" (different kinds of paper and plastic, including new materials with different textures and electrostatic properties) used for braille printing, by comparing Stroop costs to evaluate the tactile braille cues afforded by the different materials.

Conclusion

A novel tactile Stroop test has been developed and validated in this study for research purpose and can be further developed for clinical uses in order to evaluate braille reading proficiency. The tactile Stroop costs in the different testing conditions have a direct effect on educational issues related to braille reading acquisition. As young braille readers gain more proficiency and become highly skilled in tactile braille reading, the more they have difficulty in suppression of irrelevant, braille-related stimuli. Thus, braille teachers should take into consideration the fact that as they promote their students' braille reading, the suppression of other braille features may become significantly difficult. As a result, older, more proficient readers may show slowness and inaccuracy in shifting their answers to other braille features. Overcoming such difficulties needs individual educational interventions and higher awareness from both teachers and educators.

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