

# Hedonic Preferences to Audio and Visual Stimulation in Seniors with Cognitive Impairments

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## Abstract.

**Background:** Hedonic (or aesthetic) preferences to repeated sensory stimulation can remain stable over time (Island of Stability Effect, ISE) or vary with prior exposures (Mere Exposure Effect, MEE).

**Objective:** Here we compared the liking ratings of seniors with cognitive impairments (mostly mild-to-moderate dementia, DPs) and neurotypical senior controls (CNs) to audio and visual stimuli and examined whether those ratings conformed to the ISE or the MEE predictions.

**Method:** Participants ( $n = 212$ ) rated sets of stimuli repeated three times at weekly intervals: images of Picasso's paintings, PANTONE color cards, and avant-garde music clips.

**Results:** The aggregated liking ratings of DPs and CNs were stable over time, in line with the ISE model. However, latent growth modeling indicated that those stable responses might have masked differences at the individual level, since seniors in both cohorts exhibited clusters of different responses over the time evaluated, supporting the predictions of the MEE. Notably, there was a dampening of hedonic experiences in DPs comparatively to CNs.

**Conclusion:** The presence of hedonic responses (and individual variations) in DPs is relevant not only to their wellbeing and therapy interventions involving audio and visual stimulation, but also to the design of spaces that offset the downturn in hedonic experiences affecting seniors with cognitive impairments.

Keywords: Aesthetic preferences, cognitive impairments, color, dementia, island of stability effect, mere exposure effect, music, paintings

## INTRODUCTION

Hedonic (or aesthetic) experiences emerge from the dynamic combination of a wide range of entangled factors, from sensory stimulation and mnemonic processing to culture and personality traits. The initial exposure to a stimulus contributes to the creation of mental representations that are strengthened by subsequent exposures [1], but studies about the experiences of individuals with age-related cognitive

impairments to audio and visual stimulation are still relatively rare.

Leder and colleagues [2] proposed that the complexity involved in the understanding of aesthetic experiences involves five stages: perceptual analysis, explicit and implicit classifications, cognitive mastering, and evaluation. Some of those responses seem to be preserved in mild-to-moderate dementia patients (DPs), independently of the severity of their condition and their poor explicit memory [3–7], but it is likely that some stages might be affected by cognitive impairments, even if only partially.

In addition to the above roadmap to the understanding of hedonic processing, there are cognitive

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and affective hypotheses that highlight the role of familiarity in the responses to sensory stimulation [8, 9]. There are opposing views as to how neurotypical control adults (CNs) and individuals with cognitive impairments respond to repeated stimuli: one view proposes an increase (or decrease) in hedonic appreciation, while another view proposes relatively stable ratings over time.

A phenomenon observed after repeated and non-reinforced stimulation in early empirical aesthetic studies [10–12] was named the “Mere Exposure Effect” (MEE) by Zajonc [13]. A meta-analysis study showed that MEE was a reliable and robust effect, and strongest with briefly presented and unfamiliar stimuli [14]. The most common explanations for MEE responses are the (i) perceptual (or processing) fluency hypothesis, the (ii) Zajonc’s affective model, and the (iii) Berlyne’s two-factor model.

The perceptual fluency model posits that the pre-exposure to a (conscious or subliminal) stimulus could increase the ease with which it is processed, which in turn would increase the positive affect directed to the stimuli [15], possibly by reducing stimulus uncertainty [16]. In line with those findings, Reber and colleagues examined the effect of perceptual fluency on different affective judgements and showed that the exposure to visual stimuli after priming resulted in an increase in positive affect, without engaging attention or deliberate cognitive processing [17, 18].

Zajonc’s affective model of MEE postulates an evolutionary basis for the caution experienced when exposed to novel stimuli in the absence of reinforcement. The uncertainty and suspicion lessen if the repeated exposures have no negative consequences, which can lead to positive changes in affective judgements [14–16, 19, 20].

Berlyne’s two-factor model of MEE [21] postulates that habituation and satiation mediate the relationship between repetition and the hedonic response to a stimulus, evidenced as an inverted-U shaped relationship. Initially, habituation can lead to an increase in positive affect due to increased familiarity and reduced uncertainty. As the number of repeated exposures to the stimulus accumulates, the increase in affect starts being scaled down as boredom and tedium replace familiarity.

Other studies showed that hedonic responses to repeated stimulation remained relatively stable over time, the so-called “Island of Stability Effect” (ISE) [22]. Some of the early ISE accounts were not systematic and the parameters in the stimulation protocols

varied with the studies, making comparisons difficult. More recent studies indicated that to retain hedonic experiences, stored memories and associations need to be well preserved [23], which is not easily achievable in DPs. Nonetheless, mild-to-moderate DPs seem to be able to maintain and develop affective and stable dispositions toward pleasant stimuli [24], probably because some extrastriate cortical areas are relatively preserved [25] and a certain level of attention remains operative [26].

There are relatively few studies about the responses of seniors to repeated, non-reinforced audio and visual stimulation, which is surprising given the worldwide increase in longevity and consequent rise in the number of seniors, with some of them likely to develop dementia symptoms at some stage of their lives.

#### *The appreciation of music in dementia*

‘Proto MEE studies’ with DPs reported that the level of pleasantness for a musical medley increased significantly after they were played repeatedly [27, 28], but those studies lacked proper controls. There are reports of shifts in musical preferences with the onset of dementia (e.g., from classical to popular music in two DPs with frontoparietal dementia) [29], and slightly higher liking scores for classical music than jazz [30]. Music preferences have also been linked to personality traits [31] and cognitive styles [32], but some findings have been questioned in the past [28]. More recent studies showed that the appreciation of tonal music seems to be preserved in mild-to-moderate dementia, probably due to the relatively spared implicit memory and emotion networks [33, 34], and the fact that it is easy to process and retain tonal music over brief periods of time [35, 36]. Atonal music, on the other hand, tends to evoke lower emotional responses than tonal music (Ben-Tal, personal communication). Since the effect of repeated exposures to atonal music in elderly with or without cognitive impairments is unknown, this study compared DPs and CNs hedonic responses to atonal music.

#### *The appreciation of paintings and color in dementia*

Some painters diagnosed with cognitive impairments (e.g., Willem de Kooning, William Utermohlen) continued painting until advanced stages of their condition [37]. Despite the difficulties related to

safeguarding the stability of preferences over one's lifespan, Alzheimer's disease patients showed a stable appreciation of paintings and photographs of landscapes presented at brief intervals [22, 25]. Similar outcomes were observed with Parkinson's disease patients [38]. Another study reporting relatively preserved hedonic experiences in Alzheimer's disease patients used postcards with three different styles of paintings (representational or figurative, quasi-representational, abstract) [34]. It is worth noting that the paintings used in previous study were from different artists. To reduce the number of confounding variables, this study examined if DPs hedonic preferences varied with different painting styles from the *same* painter. The study also examined hedonic preferences to simpler stimuli, like postcards with light or dark versions of so-called primary colors, which has not been examined in DPs, but carried out with a large neurotypical cohort revealing significant differences in preferences [39, 40].

In a nutshell, this study is an attempt to bridge the wide gap in our knowledge about the hedonic experiences of seniors to the repeated exposure to simple and complex audio and visual stimuli in their daily environments (as opposed to the laboratory). Its aim was to examine if repeated hedonic stimulation could bypass some of the affective and cognitive deficits observed in dementia [41].

It compared the liking ratings of DPs and CNs to different categories of audio-visual stimulation and made some predictions:

- (i) Images of figurative and quasi-abstract paintings by Picasso: preferences for abstract art (i.e., less identifiable humans and objects) may be more affected by cognitive and affective impairments than representational art, with its more common and concrete forms.
- (ii) Light and muted color cards: preferences for light, more vibrant colors may induce positive affect more easily than muted, darker colors.
- (iii) Purely instrumental music clips (nonvocal) and instrumental with vocal sounds (vocal): preferences for vocal may be more affected in dementia because of the difficulties observed with voice recognition.

The understanding of hedonic experiences of seniors (CNs and DPs) to repeated audio and visual stimulation may help to clarify their mnemonic and affective associations, which in turn could help the design of individualized therapies and spaces with potential to help improving their wellbeing

[42]. Knowing how to induce positive affective experiences using relatively simple and low-cost interventions can be used as an effective form of non-verbal communication and lead to the strengthening of bonds between DPs and their relatives and carers.

## METHODS

The study received a favorable evaluation from the departmental Ethics Committee at Kingston University London, and it was in accordance with the code of Ethics of the British Psychological Society and the Helsinki Declaration of 2013. There was no potential conflicts of interest and no financial support for this research, except for departmental funding to the author for materials. Data collection was carried out by research assistants as part of their dissertation projects.

### *Participants*

The sample size was opportunistic (and larger than previous hedonic studies with DPs) and it took place over a period of about three years (2015–2017). The initial cohort had over 265 participants, but some DPs could not complete the experiments due to severe cognitive and auditory impairments, problems understanding the procedure, or needed substantial help to complete the tests, which could have biased the findings. Although 212 participants completed the study, their number varied in each of the tests and details about gender, age, and specific sample sizes are provided in Results.

The mixed DPs were recruited from care homes in London: 1) Lady Sarah Cohen House, 2) Galsworthy House, 3) Queen Ann Care, 4) Parklands Signature Manor Home, and 5) in homes across the Tower Hamlets borough. DPs were referred to the care homes by doctors, social services, or carers after the appropriate diagnosis. Most participants had completed the equivalent of secondary school, but information about further education or art expertise was not available for most participants.

The researcher assistants had to rely on the dementia diagnoses provided by care staff and the relatives of patients since the medical records were not available to them due to confidentiality regulations. The DPs diagnoses varied from Alzheimer's disease to assorted types of dementia (e.g., vascular, Lewy body, unspecified), and the observable behaviors were in line with cognitive impairments observed in those

cases. When consent was obtained, the Mini-Mental State Exam [43] was administered prior to testing (scores accepted:  $\leq 22$  out of 30).

The neurotypical elderly in the control condition (CNs) were recruited from a wide range of places: community centers, churches, charity centers, mosques, acquaintances, and bingo halls. They self-reported to have stable health, no signs of cognitive impairments, and had completed at least their primary education.

As far as it could be accessed, none of the participants were artists (professional or amateur) or were color blind, and all participants had normal or corrected-to-normal vision.

### Stimuli

It is relevant to note that relatively novel and simple stimuli can be generated for studies conducted in the laboratory, but the same is not always true in naturalistic scenarios with complex stimuli (e.g., paintings), where ‘zero’ stimulus pre-exposure is often unattainable due to the difficulty in controlling for a variety of familiar elements inherent to such stimuli. Nonetheless, precautions were taken to minimize the possibilities of pre-exposure, or at least recent pre-exposure, to the stimuli used in this study (Table 1; raw materials available at <https://osf.io/cej82/>).

### Paintings

Picasso’s paintings were chosen because they allowed for a wide choice across different styles and subjects, all created by the same artist. The images of the paintings were obtained from different websites and had dimensions in the range of  $550 \times 700$  or  $700 \times 550$  pixels. Table 1 lists the 12 Picasso’s paintings selected, which were split into “figurative” (also referred to as “representative” in some studies) or “quasi-abstract”, depending on whether they contained easily recognizable objects and humans, or the content was fuzzier (e.g., distorted, or schematic faces, unrecognizable objects).

### Color cards

Ten PANTONE color cards with five highly chromatic color samples (red, blue, green, yellow, and magenta) were used. The color cards (see color codes in Table 1) were selected by a pilot group with nine participants. The group selected five pairs of color cards representing “light” and their “muted” hues. The terms light and muted are subjective; they refer to the perceived lightness in a broader sense because the lighting conditions in the places where participants were tested could not be controlled [39].

### Avant-garde music

The six audio clips (Table 1) were created by Luigi Nono (two) and Oded Ben-Tal (four); the latter musi-

Table 1  
List of the paintings, color, and music stimuli used in the study

1. PAINTINGS (Picasso)	
Quasi-abstract	Figurative
Femme assise (1929)	Arlequin assis sur un canapé rouge (1905)
Françoise Gilot avec Paloma et Claude (1951)	Mère et enfant (1921-22)
Les demoiselles d’Avignon (1907)	Deux femmes courant sur la plage (1922)
Femme Assise dans un Fauteuil Rouge (1932)	Portrait de la mère de l’artiste (1896)
Femme en pleurs (1937)	Jacqueline de Vauvenargues (1959)
2. COLOR CARDS (Pantone color code)	
Light	Muted
Yellow (108)	Yellow (14–0848)
Red (485)	Red (18–1248)
Blue (291)	Blue (19–3935)
Green (350)	Green (7737)
Magenta (214)	Magenta (15–1816)
3. MUSIC Avant-garde (Oded Ben-Tal & Luigi Nono)	
Instrumental only ( <i>nonvocal</i> )	Vocal & Instruments ( <i>vocal</i> )
inst-nono	voice-hour
inst-oded-qtt	voice-mits
inst-soli	voice-nono

The paintings were sourced from online images and presented on a laptop (duration: 40 s/slide) and the color cards were from PANTONE (duration: 40–60 s/card). The music clips were either (i) created by Luigi Nono and Oded Ben-Tal and were not available commercially at the time of the study (duration: 35–40 s). The stimuli are available at the OSF: <https://osf.io/cej82/>.

cian is based at the Music department at Kingston University London. Half of the music clips were non-vocal, and half were vocal (i.e., vocal-like sounds added to the instrumental sounds). Dr. Ben-Tal normalized the loudness so that the peak level of all audio clips was the same in all audio clips. The audio format used was not compressed (.wav files) and lasted about 40 s/each. They were chosen because it was highly unlikely that any of the participants had heard them prior to testing since the songs were either never released to the public or had a very restricted audience.

Note that due to hearing impairments and the short duration of the music clips, some of the elderly recruited over a period of more than two years could not take part in the study. Unfortunately, the exact number of excluded participants was not annotated by all researchers.

### *Procedure*

Consent was provided by DPs as well as by their caregivers or guardians (when known) and care-home managers. To minimize disruptions in the DPs daily routines, the tests were conducted in spaces familiar to them. The test with CNs who agreed to take part in the study were run in the social spaces where they had been initially approached.

Each of the three tests (i.e., paintings, color cards, avant-garde music) lasted about 15 min and the participants seemed to enjoy them, especially DPs. Each participant was asked to complete the tests once a week, for three consecutive weeks. The order of presentation of each of the three sets of stimuli was pseudo-randomized from one week to the next. Participants were required to rate how much they liked each of the stimuli separately. A Likert scale (“0” for “strongly dislike it” to “6” for “strongly like it”) was printed on an A4 page. After looking or listening to the stimuli, participants indicated how much they liked or disliked them by pointing their liking rating on the printed scale and the researcher recorded the responses on separate spreadsheets.

Before each of the weekly tests, researchers checked if DPs recognized any of the test materials used in the previous visit(s), but nobody reported remembering the tests (nor the researchers). Although the duration of the stimulus presentation was controlled, the participants had as much time as they needed to give their answers and the instructions were repeated between stimulus presentation whenever necessary.

### *Painting test*

The paintings were displayed on a laptop screen (~15 in) one at a time for 40 s/each using a PowerPoint presentation. Participants had to give their liking rating after an image had been presented before being shown the next one.

### *Color card test*

Both CNs and DPs hold each PANTONE color card briefly before rating them. The duration of the presentation lasted about one minute (controlled with a stopwatch). Note that lighting conditions during testing could not be controlled and variations in spectral light are known to affect color perception significantly. Nonetheless, the test was carried out to examine if there were major differences between the two cohorts due to the relevance of color in living environments for the elderly with and without dementia.

### *Music test*

Participants were fitted with over-the-ear headphones. The volume was adjusted for each participant until they said they could hear the music clearly—a music piece not used in the test was used to adjust the sound level.

### *Data analysis*

The liking ratings to the different categories of stimuli were the dependent variable; the two health conditions (DPs × CNs) and the presentation week were the independent variables. The distribution of the response frequencies was accepted as normal when the kurtosis was within the  $\pm 2$  range. Although this study has a much larger sample size than previous studies on aesthetic experiences in dementia, the observed (i.e., *post hoc*) power is not meaningful because it is knowingly low when the effects reported are mostly non-significant.

Repeated measures ANOVA, with Greenhouse–Geisser adjustments to the degrees of freedom when sphericity could not be assumed (Mauchly’s sphericity test), was adopted for the data analysis. Bonferroni adjustments were used in pairwise comparisons, and partial eta-square ( $p\eta^2$ ) refers to effect size with approximate cut-off values: 0.01 small/modest, 0.06 medium/moderate, and 0.14 large (such values need to be taken as “rules of thumb” rather than precise boundaries [44, 45]). Additionally, estimation statistics [46] was used to provide graphs that illustrate the individual responses of each of the participants

to each of the tests used, as well as Cohen’s *d* values, which in this case allow a visual evaluation of effect size:  $d \geq 0.2$  for small,  $d \geq 0.5$  for medium, and  $d \geq 0.8$  for large effects.

**RESULTS**

The effect sizes obtained from ANOVA are reported as  $p\eta^2$  and the Cohen’s *d* for pair comparisons can be seen in estimation plots for each set of stimuli.

*Paintings*

There were 88 participants: 42 DPs (25 females, 17 males; mean age = 83.57 years,  $SD = 8.73$ , % 95 CI [80.73, 85.70]) and 46 CNs (32 females, 14 males; mean age = 75.17 years,  $SD = 8.32$ , % 95 CI [75.07, 81.14]).

A 2 (health condition: DPs × CNs) by 3 (exposure week: 1 to 3) ANOVA revealed no significant main effect of repeated exposures to the Picasso paintings,  $F(2,172) = 1.02$ ,  $p = 0.36$ ,  $\eta_p^2 = 0.01$ , and no interac-

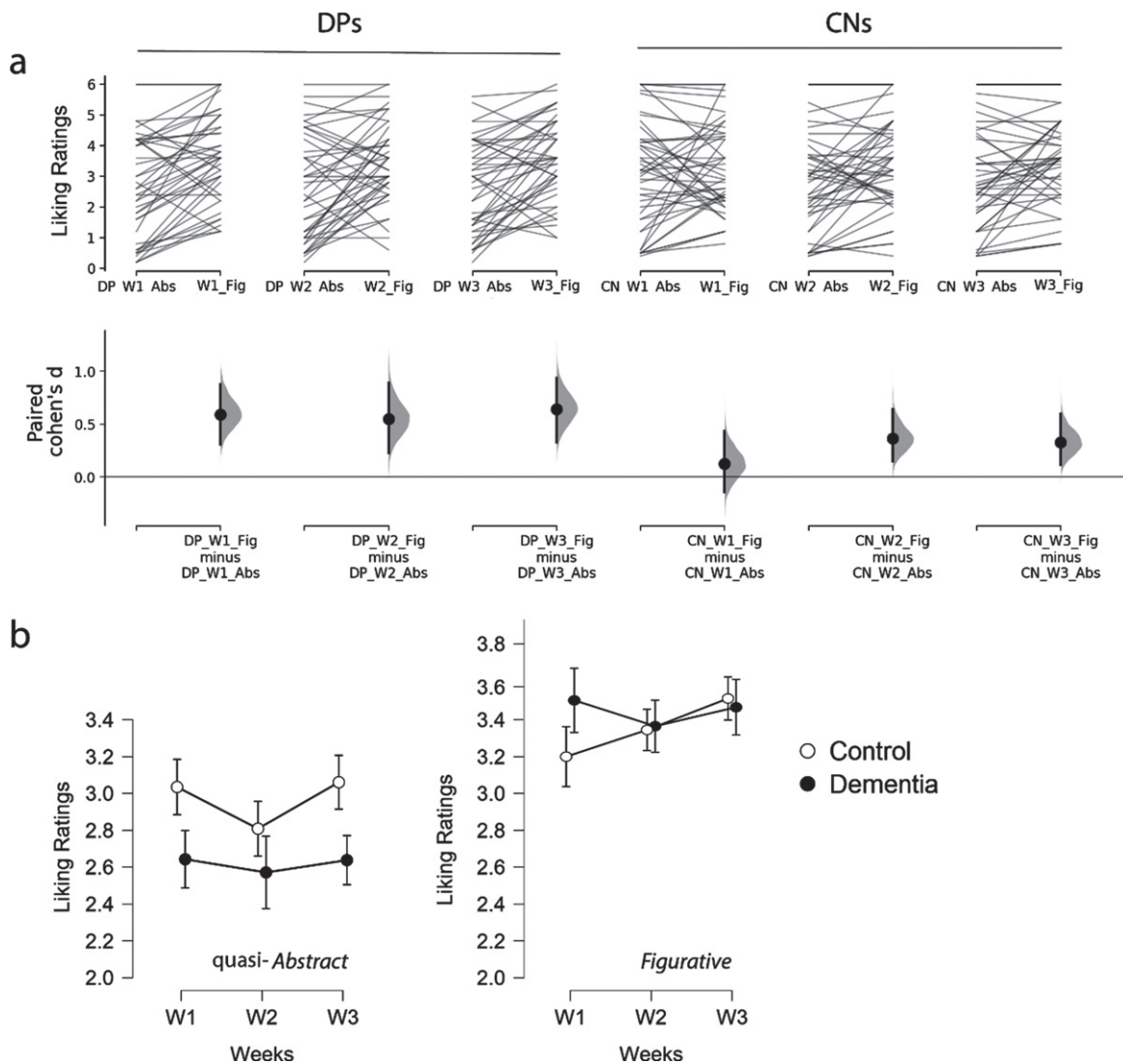


Fig. 1. The liking ratings of dementia (DP) and healthy elderly controls (CN) for images of Picasso’s paintings from his figurative period and his later quasi-abstract period. a) Cumming estimation plots with the paired Cohen’s *d* for six comparisons. Each paired set of observations for each participant is connected by a line. They show the means for the three weeks of the study (W1 to W3) in each cohort. The lower axis shows the Cohen’s *d* for each comparison. The 95% confidence intervals are indicated by the ends of the vertical error bars. b) Mean liking ratings ( $\pm SE$ ) for each week and condition are summarized. Open circles show the mean ratings of CN and closed circles the ratings of DP.

tion with the health condition ( $F < 1$ ) (Fig. 1a, b). The aggregated liking rating in CNs ( $M = 3.21, SE = 0.19$ ) and DPs ( $M = 3.08, SE = 0.20$ ) was statistically similar,  $F < 1$ . A subsequent analysis with a 2 (style: quasi-abstract  $\times$  figurative) by 2 (health condition: DPs  $\times$  CNs) by 3 (exposure: 1 to 3 weeks) uncovered a significant main effect of painting style,  $F(1, 86) = 29.20, p < 0.001, \eta^2 = 0.25$ ; the aggregated ratings for quasi-abstract paintings ( $M = 2.79, SE = 0.17$ ; DPs = 2.62, CNs = 2.97) was lower than

the aggregated ratings for figurative paintings in the two health conditions ( $M = 3.50, SE = 0.14, DPs = 2.97, CNs = 3.45$ ), ( $p < 0.001$ ). No other interactions were significant ( $ps > 0.091$ ), even though there was a trend for CNs to give slightly higher ratings to quasi-abstract paintings than DPs.

Figure 1a shows the paired responses of DPs and CNs, which remained relatively stable during the three weeks. The two cohorts rated figurative paintings equally high (Fig. 1b). There were contrasting

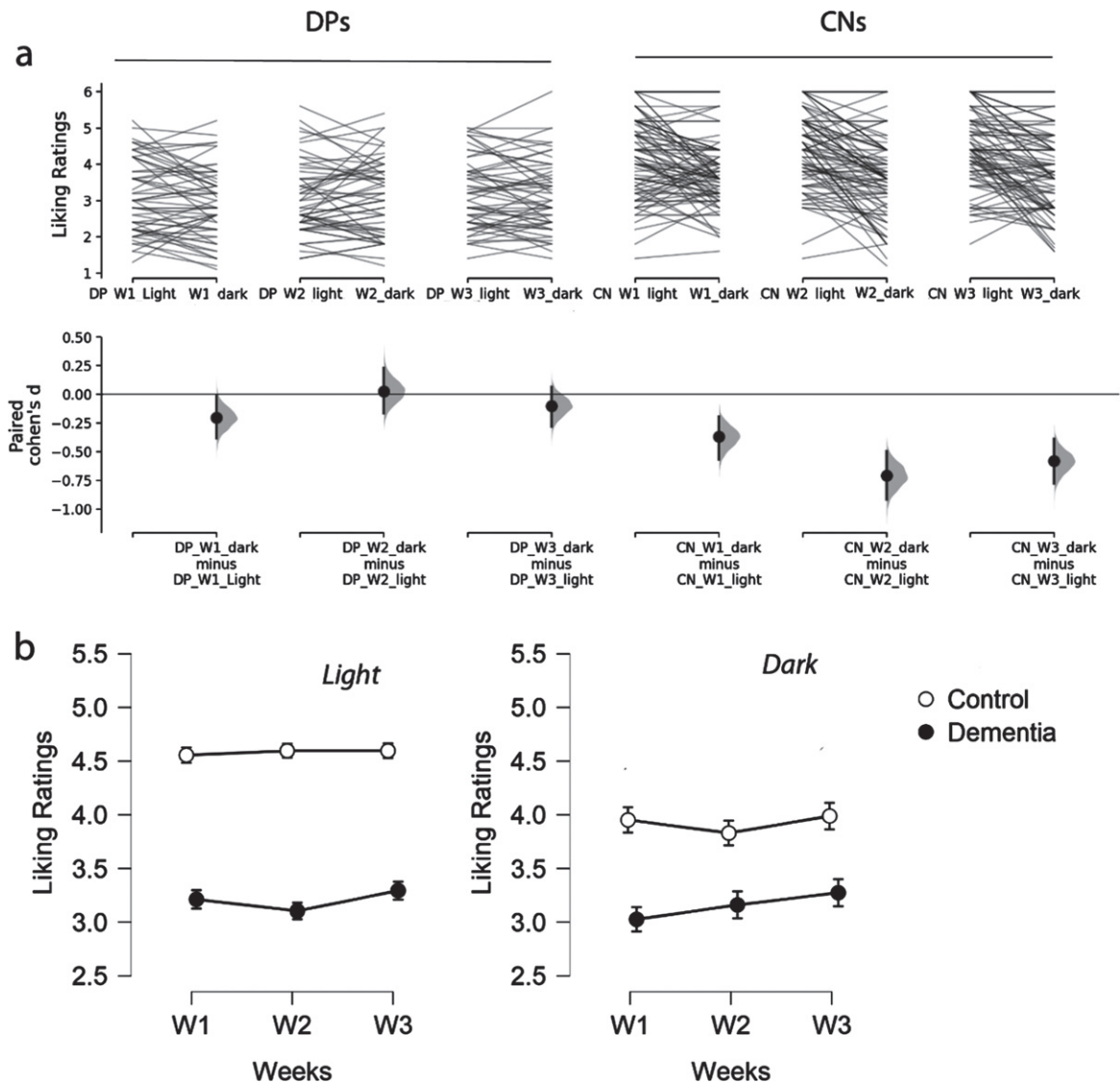


Fig. 2. The liking ratings of dementia (DP) and healthy elderly controls (CN) for five pairs of color cards (red, blue, green, yellow, and magenta) containing a light and a dark, more muted version of each hue. a) Cumming estimation plot with the paired Cohen's  $d$  for six comparisons. The comparisons show the means for the three weeks of the study (W1 to W3). Each paired set of observations for each participant is connected by a line. The lower axis shows the Cohen's  $d$  values. The 95% confidence intervals are indicated by the ends of the vertical error bars. b) Mean liking ratings ( $\pm SE$ ) for each week and condition are summarized. Open circles show the mean ratings of CN and closed circles the ratings of DP.

individual differences within each of the two cohorts: most participants preferred figurative over quasi-abstract paintings, but some participants showed the opposite response.

**Color cards**

There were 146 participants: 56 DPs (38 females, 18 males; mean age = 81.46 years,  $SD = 8.63$ , % 95 CI [79.14, 83.78]) and 90 CNs (61 female, 29 males; mean age = 78.00 years,  $SD = 7.51$ , % 95 CI [76.12, 79.89]).

As observed with paintings, a 2 (health condition: DPs × CNS) by 3 (exposure: 1 to 3 weeks) ANOVA showed no reliable differences in liking rat-

ings for color cards along the three weeks of testing,  $F(2,288) = 2.92$ ,  $p = 0.056$ ,  $\eta^2 = 0.020$ . On the other hand, the ratings of CNs ( $M = 4.09$ ,  $SE = 0.10$ ) were significantly higher than the ratings of DPs ( $M = 3.09$ ,  $SE = 0.12$ ),  $F(1, 144) = 42.84$ ,  $p < 0.001$ ,  $\eta^2 = 0.229$  (Fig. 2a, b).

A 2 (color type: light × dark/muted) by 2 (health condition: DPs × CNS) by 3 (exposure: 1 to 3 weeks) ANOVA revealed a main effect of color lightness,  $F(1,144) = 45.36$ ,  $p < 0.001$ ,  $\eta^2 = 0.240$ , and a significant interaction with the health condition,  $F(1,144) = 24.48$ ,  $p < 0.001$ ,  $\eta^2 = 0.145$  (Fig. 2a). There was also an interaction between color type and weeks of exposure,  $F(2, 288) = 5.69$ ,  $p = 0.005$ ,  $\eta^2 = 0.038$ .

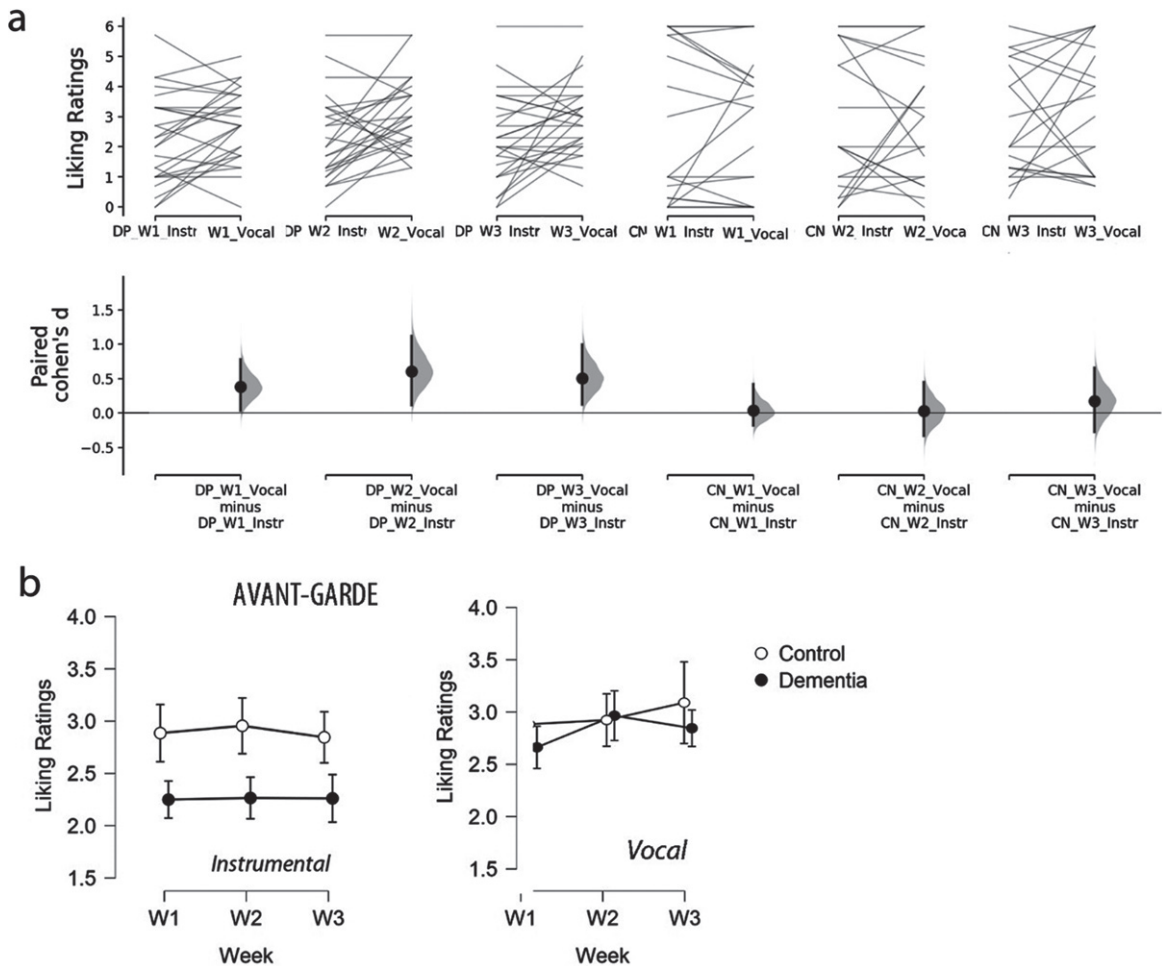


Fig. 3. The liking ratings of dementia (DP) and healthy elderly controls (CN) for avant-garde music clips with voices (vocal and instrumental) or nonvocal (i.e., instrumental only). a) Cumming estimation plots with the paired Cohen's *d* for six comparisons. The comparisons show the means for the three weeks of the study W1 to W3). Each paired set of observations for each participant is connected by a line. The lower axis shows the Cohen's *d* values. The 95% confidence intervals are indicated by the ends of the vertical error bars. b) Mean liking ratings ( $\pm SE$ ) for each week and condition are summarized. Open circles show the mean ratings of CN and closed circles the ratings of DP.



CNs significantly preferred lighter than darker color cards,  $F(1,89) = 73.06$ ,  $p < 0.001$ ,  $\eta^2 = 0.451$ . A pairwise comparison of CNs responses showed that cards judged as having lighter colors were rated higher ( $M = 3.76$ ,  $SE = 0.08$ ) than the cards with the darker, more muted colors ( $M = 3.42$ ,  $SE = 0.08$ ,  $p < 0.001$ ) (Fig. 2).

The color preference across the three weeks in terms of mean ratings for hues (yellow, red, blue, green, and magenta) differed significantly,  $F(1,576) = 6.84$ ,  $p < 0.001$ ,  $\eta^2 = 0.045$ , with DP ratings overall lower than the CN ratings,  $F(1,144) = 42.78$ ,  $p < 0.001$ ,  $\eta^2 = 0.229$ . Red cards received the lower ratings from DPs and CNs. DPs preferred magenta cards, while CNs preferred yellow ones. No further statistical analysis was carried out because calibrated monitor displays could not be used in the settings where the data were collected.

#### *Avant-garde music*

There were no studies about preferences for atonal music in dementia or neurotypical seniors prior to our data collection, which made it hard to know in advance how the stimuli would be perceived by the seniors. Nonetheless, it is important to evaluate the data, as it can guide future studies in the area.

This study had 46 participants: 26 DPs (17 females, 9 males; mean age = 85.19 years,  $SD = 7.91$ , %95 CI [82.30, 88.09]) and 20 CNs (12 females, 8 males; mean age = 79.50 years,  $SD = 8.21$ , % 95 CI [74.20, 80.80]).

The aggregated ratings for avant-garde music clips with vocals and nonvocal did not increase significantly with three repeated exposures to those sounds,  $F(2,88) = 0.20$ ,  $p = 0.820$ ,  $\eta^2 < 0.01$ . When the ratings for the two types of music were aggregated, DPs ( $M = 2.59$ ,  $SE = 0.28$ ) and CNs ( $M = 2.98$ ,  $SE = 0.32$ ) showed similar responses,  $F(1,44) = 0.85$ ,  $p = 0.360$ ,  $\eta^2 = 0.02$ . However, a subsequent analysis with 2 (health condition)  $\times$  3 (week of exposure)  $\times$  2 (type of music: vocal versus nonvocal) showed a significant effect of the type of music,  $F(1,44) = 5.48$ ,  $p = 0.02$ ,  $\eta^2 < 0.11$ . Overall, music with no vocals ( $M = 2.58$ ,  $SE = 0.25$ ) was rated less favorably than music with vocals ( $M = 2.99$ ,  $SE = 0.21$ ,  $p = 0.024$ ) (Fig. 3a). The mean rating of CNs for nonvocal music was slightly higher than in DPs, but the trend was not significant (Fig. 3c).

A separate analysis of the ratings for each of the two cohorts (3 week of exposure  $\times$  2 type of music) revealed that differences in ratings between

vocal and nonvocal music was only observed in DPs,  $F(1,25) = 14.23$ ,  $p < 0.001$ ,  $\eta^2 < 0.36$ .

#### *Individual differences*

There were no reliable gender differences for any of the aggregated liking ratings ( $ps > 1$ ), but the data showed different individual patterns of response after repeated exposures to the stimuli. Such differences are illustrated in the top panels of Figs. 1–3, which show the individual responses of CNs and DPs for each set of stimuli. The interception and the slope of the linear interpolations for the participants in the different cohorts suggested that the liking ratings of some participants increased with repeated exposures and some decreased, with a small number of participants showing no changes over time.

As it was a *post-hoc* observation (i.e., not part of the original hypotheses), the latent growth model [47, 48] was used to evaluate if the effect of repeated exposures to paintings, color cards, and avant-garde music varied systematically or if the differences in intercepts and linear slopes were due to normal variations in response. Three models were tested: Model 1 assumed the intercepts were random, but the slopes were fixed; Model 2 assumed the intercepts were fixed, but the slopes were random; and Model 3 assumed intercept and slope varied systematically.

Table 2 summarizes the findings for DPs and CNs. The comparative fit index (CFI) indicates how well a model fits to the data, with 1 indicating a perfect fit. The standardized root mean square residual (SRMR) is another measure of fit and a value equal or smaller than 0.08 is usually considered a good fit. Even though the CFI for avant-garde music was not as good as the CFI for paintings and color cards, probably due to the smaller sample size, the SRMR values were low for all conditions.

Model 3 showed the best overall fit to the data; the intercept and the slope of the linear fits varied systematically across participants in each of the cohorts. This finding highlights the importance of establishing individual aesthetic thresholds prior to testing.

## **DISCUSSION**

Hedonic (or aesthetic) experiences can emerge from the interaction between the perceptual features of artworks and other objects and the perceptual dynamics of the observer's sensory processes. This study examined the effect of repeated exposures

Table 2

Latent growth model specifications for the liking ratings for abstract and figurative Picasso paintings, light and dark color cards, and avant-garde music with voice-like sounds or solely instrumental

Model	$\chi^2$	CFI	RMSEA	SRMR	Intercept mean	$\Delta$ Residual	Slope mean
<i>Paintings</i>							
1. Intercept							
DP	1522.9	0	0.48	0.41	3.08	1.83	–
CN	2392.24	0	0.6	0.48	3.21	2.17	
2. Random Intercept							
DP	158.31	0.899	0.16	0.07	3.08	0.58	–
CN	84.72	0.967	0.12	0.05	3.21	0.4	
3. Random Slope							
DP	149.01	<b>0.904</b>	0.17	0.05	3.08	0.63	–
CN	68.63	0.973	0.12	0.04	3.19	0.36	
4. Random Intercept & Slope							
DP	148.14	<b>0.903</b>	0.23	0.05	3.09	0.62	–0.01
CN	32.81	<b>0.978</b>	0.1	0.03	3.12	0.36	0.03
<i>Color Cards</i>							
1. Intercept							
DP	1755.74	0	0.51	0.43	3.09	0.88	–
CN	2920.43	0	0.66	0.5	4.09	0.96	
2. Random Intercept							
DP	98.82	0.947	0.13	0.05	3.09	0.24	–
CN	144.81	0.952	0.16	0.03	4.09	0.14	
3. Random Slope							
DP	69.96	0.963	0.12	0.07	3.07	0.2	–
CN	64.13	0.98	0.11	0.06	4.07	0.1	
4. Random Intercept & Slope							
DP	6.22	<b>0.998</b>	0.03	0.02	3.02	0.18	0.08
CN	20.93	<b>0.994</b>	0.08	0.01	4.05	0.09	0.05
<i>Music</i>							
1. Intercept							
DP	804.02	0	0.35	0.32	2.58	1.3	–
CN	3185.55	0	0.69	0.52	2.01	4.19	
2. Random Intercept							
DP	61.66	0.928	0.1	0.08	2.58	0.62	–
CN	1.26.04	0.664	0.42	0.21	2.01	0.84	
3. Random Slope							
DP	51.9	0.94	0.1	0.08	2.59	0.65	–
CN	800.3	0.738	0.41	0.6	2.25	0.32	
4. Random Intercept & Slope							
DP	43.35	<b>0.948</b>	0.12	0.07	2.53	0.66	0.05
CN	75.53	<b>0.976</b>	0.16	0.02	2.34	0.29	–0.33

CFI, comparative fit index; SRMR, standardized root mean square residual; RMSEA, root mean square error of approximation; DP, dementia patients; CN, neurotypical controls. CFI values in bold indicated the highest values.

to audio and visual stimulation in mixed dementia patients (mild-to-moderate symptoms; DPs) and in neurotypical seniors (CNs) when tested in everyday settings. More specifically, it investigated if the liking ratings to images of Picasso paintings, PANTONE color cards, and atonal music in DPs and CNs were stable across repeated exposures (as predicted by the ISE model), or if they increased/decrease with exposure (as predicted by the MEE models).

Two sets of stimuli were relatively complex (avant-garde music clips and Picasso paintings) and one set was relatively ubiquitous and simple (color cards).

The avant-garde music clips were novel stimuli, but the novelty of the Picasso paintings was not clear. One could argue that participants were familiar with the paintings, but it is unlikely they had seen the 12 paintings used in this study repeatedly and the presentation format (slides on a computer screen) was novel for them.

The first set of findings showed that DPs and CNs preferred paintings with recognizable humans and objects (figurative), from earlier phases of Picasso's work rather than the paintings with quasi-abstract and distorted contours characteristic of his Cubist

phase. Although the two cohorts liked the figurative paintings more than the quasi-abstract ones, the ratings to the latter style were lower in DPs than CNs. This is congruent with the findings of Boutoleau-Bretonnière and colleagues (2016), who examined the hedonic evaluations of 15 patients with frontotemporal dementia using a “beautiful-to-ugly” scale and reported that they rated the abstract paintings as uglier than the control cohort, probably due to difficulties with abstraction linked to impaired cognitive processes and attentional difficulties. Despite the differences observed with the painting styles, the aggregated liking ratings of DPs and CNs remained relatively stable across the three repeated exposures.

The liking ratings for light and dark, muted color cards were relatively similar across exposures and significantly lower in DPs than CNs. CNs liked lighter color cards more than their muted pairs across all weeks. Most CNs showed a stronger preference for yellow cards, whereas DPs preferred magenta ones, and both cohorts preferred the lighter version of the red cards than the muted color cards. The dislike of the dark red card, which had a brownish likeness, might be linked to associations with feces, rotten meat, and other forms of decay, an explanation posited by Palmer and Schloss [39] among others. Interestingly, neurotypical adults in another study [49] preferred purple (a color not too dissimilar to magenta) over yellow, which mirrored the preferences of DPs (but not CNs) in this study. The reasons for such discrepancy are not known and might be, at least partially, related to poor control of color calibration in natural settings (unlike the monitors used in previous laboratory studies).

In short, the findings with color cards are in line with the study of Taylor and colleagues [49], who reported that typical adults preferred lighter hues than darker ones. They are also partially aligned with reports that the cognitive decline in dementia affected the naming of complex color combinations, but color preference remained stable [50].

Avant-garde music clips with vocal sounds were favored by DPs and CNs. Previous studies confirmed that familiarity with voices appears to have been spared in mild-to-moderate dementia due to relatively spared implicit memory processing [33, 34]. It is worth noting, though, that impairments in voice recognition in severe cases of dementia are common [51]. Interestingly, the liking ratings to nonvocal avant-garde music were dampened in DPs in comparison to CNs.

The aesthetic responses of DPs and CNs were relatively stable over time and conformed with the predictions of the ISE model. The idea that DPs have an hedonic “island of stability” because they are not burdened by the semantic and emotional influences that could affect the preferences of controls [22] could not be confirmed, though, since relatively stable aesthetic responses were also observed in CNs.

Interestingly, at the individual level, the responses to repeated exposures to the three sets of stimuli were not as uniform as the cohort’s averaged responses suggested. In some cases, when the baseline liking rating for a given stimulus was lower than the cohort’s average, further exposures led to an increase in ratings by Week 3. Conversely, higher baseline ratings than the cohort’s average often led to a decrease in ratings with further exposures. The opposing responses could have accounted for the overall “stability” in the aggregated ratings for DPs and CNs over time. Those observations were confirmed by the latent growth model, which suggested that the initial level of hedonic appreciation varied among individuals in both cohorts.

Caution is needed when drawing conclusions based on the findings of latent growth modeling, though, since it was triggered by a *post-hoc* observation and some of the parameters would have benefitted from a larger sample size. Nonetheless, the model findings suggest that the hedonic responses of DPs and CNs could conform with the two-factor model of MEE posited by Berlyne [21] or even the perceptual fluency model [52]. The decrease in ratings could be linked to an affective “wear out” caused by previous exposures to similar or related stimulation, which would raise the internal noise in a hedonic processing system and “down-play” the responses to tested stimuli, as suggested in predictive models [53, 54]. Alternatively, repeated stimulation could have triggered a preference transfer through fluency [18] or implicit learning [55] and further exposures would lead to a decline in liking due to satiation or boredom [56]. The increase in liking ratings could indicate that the stimuli were novel and satiation had not been reached, or that changes in internal states lead to positive evaluations. For example, the increase in affect for paintings and atonal music after repeated exposures observed at the individual level is in line with previous studies [25, 57–60].

Despite of the large number of DPs in this study in comparison to previous empirical studies, there were several limitations. As mentioned previously, the neurological heterogeneity of DPs might have masked

yet unknown dementia-specific cognitive and affective impairments modulating hedonic preferences. A more homogeneous DP cohort is needed to confirm and expand the findings reported here. Interestingly, a study by Halpern and O'Connor [61] reported that a more homogenous group of patients (frontotemporal dementia) also showed stable preferences for figurative, quasi-abstract (i.e., quasi-figurative) and abstract paintings over two exposures a week apart. Another study limitation was the number and interval of the repeated presentations of the stimuli, because the care homes access to their residents was restricted to one test session per week. Furthermore, the tests with color cards and images of paintings could not be carried out under controlled laboratory lighting conditions (c.f. [62]).

Given that the increase in human longevity is associated with increases in the number of dementia cases, an even higher demand for more care facilities for seniors is expected. The understanding of the aesthetic experiences of neurotypical and cognitively impaired seniors is essential to their care and wellbeing [41, 63, 64]. The findings indicated that most DPs were able to maintain a certain level of focused attention and affective dispositions towards audio-visual stimulation, even though their hedonic responses were often lower than the those of CNs. The dialing-down of hedonic experiences in mild-to-moderate dementia is in line with earlier studies with a shorter range of stimuli [64–66], and it is important to counteract such reduction in pleasurable sensory experiences. The exposure to music, for example, can enhance memory and emotion processing [67, 68]. Nonverbal positive experiences in living environments can strengthen the bonding between DPs and their relatives and carers [69, 70], and the rehabilitative use of hedonic stimulation in general can counteract some of the memorization deficits observed in dementia [19, 24, 25].

Finally, the findings highlight the importance of establishing individual hedonic thresholds prior to testing in order to raise the effectiveness of therapeutic interventions for cognitively impaired seniors involving audio and visual art, which may be also relevant to the design of appropriate spaces to promote the wellbeing of our aging population.

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