Face and Body Recognition Show Similar Improvement During Childhood.

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Abstract

Adults are proficient in extracting identity cues from faces. This proficiency develops slowly during childhood with performance not reaching adult levels until adolescence. Bodies are similar to faces in that they convey identity cues and rely on specialized perceptual mechanisms. However, it is currently unclear whether body recognition mirrors the slow development of face recognition during childhood. Recent evidence suggests that body recognition develops faster than face recognition. Here we measured body and face recognition in 6- and 10-year-olds and adults to determine if these two skills show different amounts of improvement during childhood. We found no evidence that they do. Face and body recognition showed similar improvement with age, and children, like adults, were better at recognizing faces than bodies. These results suggest that the mechanisms of face and body memory mature at a similar rate or that improvement of more general cognitive and perceptual skills underlies improvement of both face and body recognition.

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Face and Body Memory Show Similar Improvement During Childhood

Successful social interaction depends on our ability to accurately identify others. Faces are a rich source of identity information and adults can readily determine a person's identity from his or her face (Adolphs, 2003; Bruce & Young, 1986; McKone, Crookes, Jeffery, & Dilks, 2012). Given that all faces are highly similar visual patterns this is an impressive skill that is supported by face-specific perceptual and neural mechanisms (e.g., Kanwisher, McDermott, & Chun, 1997; Maurer, Le Grand, & Mondloch, 2002; Rhodes, 2013; Rhodes & Leopold, 2011; Tong, Nakayama, Moscovitch, Weinrib, & Kanwisher, 2000).

There has been considerable interest in how face recognition skills develop and the role of experience during childhood in refining face-specific mechanisms. It is well established that performance on face recognition tasks improves from six years to adulthood (e.g., Bruce et al., 2000; Carey, Diamond, & Woods, 1980; Chung & Thomson, 1995; Mondloch, Geldart, Maurer, & Le Grand, 2003). These findings have led researchers to argue that the perceptual and neural mechanisms of face recognition develop during childhood as experience with faces accumulates (e.g., Diamond & Carey, 1977; Golarai et al., 2007; Mondloch, Le Grand, & Maurer, 2002, and see McKone et al., 2012, for a review).

Bodies also convey identity cues and, like faces, the similarity of bodies presents a challenge to the visual system. Relatively little is known about body recognition skills. In adults there is some evidence that body perception relies on perceptual mechanisms similar to those used for faces (Reed, Stone, Grubb, & McGoldrick, 2006; Rhodes,

Jeffery, Boeing, & Calder, 2013; Robbins & Coltheart, 2012a, 2012b). These similarities between the mechanisms of face and body recognition in adults, and the fact that experience with bodies also accumulates during childhood suggest that body recognition may also show prolonged development.

Recognition of whole-person stimuli (face and body together) improves between the ages of 4 and 10 (Seitz, 2003). However, this improvement could simply reflect the well-established improvement in face recognition. Body-only recognition in children has only been examined in three studies but all three suggest that body-only recognition improves with age. Seitz (2002) found that body recognition (whole person stimuli were used but the faces were held constant) improved between ages 8 and 10 and the amount of improvement did not differ from that found for faces only. They did not test younger children. Peelen, Glaser, Vuilleumier and Eliez (2009) showed that a group of children (7-17 years-old) were less accurate but no slower than a group of adults at performing a one-back image matching task using body-only stimuli (no heads shown). However, they did not present any analyses examining whether performance may have varied with age among their child sample. Weigelt et al (2014) used old-new recognition tasks to test recognition for bodies, faces, cars and scenes in 5- to 10-year-old children and adults. Body recognition improved with age but interestingly the improvement in body recognition between ages 5 to 10 was smaller than the improvement in face recognition over this age range. Further, the age-related changes in body recognition were comparable to those found for cars and scenes. These results suggest that body and face recognition skills may develop at different rates between ages 5 and 10. Moreover, inspection of Weigelt and colleagues' results suggests that body recognition performance

reached adult levels around 7-8 years-of-age whereas face recognition performance did not approach an adult level until 10 years-of-age. Therefore it is possible that body recognition skills mature earlier in development than face recognition skills.

Interestingly, the unique developmental trajectory seen for faces in this study was restricted to face *memory*. Weigelt et al (2014) found similar age-related improvement for faces, bodies, cars and scenes on tests of face *perception* (discrimination task) that had minimal memory demands.

However, there are several limitations in Weigelt et al's (2014) study that complicate the interpretation of their results as evidence that body and face recognition improve at different rates during development. First, stimuli were identical at study and test, raising the possibility that image-memory, rather than object memory, may have contributed substantially to the tasks. Second, face stimuli were derived from photographs but the body stimuli were computer-generated images, raising questions about how well the latter tapped body recognition skills and how comparable the face and body tasks were. Third, participants always studied two sets of objects (e.g. faces and cars) prior to the memory test, so that any age differences in interest in or attention to one category over the other could have influenced recognition performance. Indeed, there is evidence that children find cars more interesting than faces (Ewing, Pellicano, & Rhodes, 2013).

In the present study we asked whether body recognition improves less than face recognition during childhood using a design that overcomes these problems. We used an old-new paradigm to assess recognition of faces and bodies. A two-alternative forced choice task assessed participants' abilities to identify face-only and body-only stimuli

that had been shown in a study set. Faces and bodies were taken from photographs of the same individuals to provide a realistic test of the relative ability to identify faces and bodies. Adults typically find faces easier to recognize than body-only images of the same individuals (Burton, Wilson, Cowan, & Bruce, 1999; O'Toole et al., 2011) but no studies have investigated whether this is also true for children. If children's body recognition skills are more advanced than their face recognition skills it is possible that children will not show this face advantage. In addition we varied image characteristics between study and test to minimize image matching. Children aged six and ten years old were tested. These age groups were chosen because it is well established that face recognition performance improves over this age range (e.g., Bruce et al., 2000; Carey et al., 1980) and because these age groups roughly correspond to the ages spanned in Weigelt et al's study (2014). Adults were also tested to allow us to assess the maturity of children's skills.

When testing such a wide age range care must be taken to avoid floor and ceiling effects because they make it difficult to interpret any differences in the amount of age-related improvement that is found for different categories of stimuli (Carey, 1981; Crookes & McKone, 2009; McKone et al., 2012). Weigelt et al (2014) sought to avoid these effects by selecting stimuli so that performance was matched across all four stimulus classes in the 10-year-old age-group. However, this approach masks natural differences in difficulty in recognizing different classes of stimuli. Another approach is to match difficulty across age groups by varying the number of items to be remembered so that, for example, adults study more items than children (e.g., Crookes & McKone, 2009; Gilchrist & McKone, 2003). However, this method has the disadvantage that children's

and adults' scores are not based on identical items. To overcome this latter disadvantage we tested participants of all ages on sets that included 3, 6 or 12 items. Our procedure had several advantages. First, by starting with relatively easy trials (sets of 3) participants gained confidence and were not discouraged early on by the difficulty of the task. Second, because all participants completed all set sizes we could collapse across set size and calculate a total score, based on a relatively large number of trials that were identical for all participants. Third, if any age group showed ceiling or floor effects in these total scores, we could conduct alternative analyses, using only data from set sizes uncontaminated by such effects.

If children's body and face recognition skills develop at different rates then we expect to observe different amounts of age-related improvement on our face and body tasks. Moreover, if children's performance is closer to adult levels than their face recognition performance this will suggest that body recognition improves more rapidly than face recognition. Also, we expected adults to be better at recognising faces than bodies (Burton et al., 1999; O'Toole et al., 2011) but if body recognition develops more rapidly than face recognition then young children may not show this face advantage. Rather they may do equally well with both faces and bodies, or even show superior performance for bodies over faces. If children do show a face advantage, differences in size of this advantage across age groups will indicate that body and face recognition showing differential improvement with age.

Methods

Participants

Twenty-eight 6-year-olds ($M = 6:7$ years, $SD = 5$ months, Range = 5:3-7:1, 18 female) and 35 10-year-olds ($M = 10:8$ years, $SD = 5$ months, Range = 9:6-11:8, 23 female) were recruited from five schools in the XXXX metropolitan area. Twenty-two undergraduate psychology students ($M = 21$ years, $SD = 8$ years, Range = 17-53, 18 female) were also recruited from the University of XXX. The majority of participants in each age group had lived in Australia or another western country (e.g., Ireland, New Zealand) for all their lives (75% of 6 year-olds, 74% of 10 year-olds and 91% of adults¹. Parents or guardians, children and undergraduates provided written informed consent prior to testing. Undergraduates participated for course credit.

Stimuli

Full-body photographs of 72 Caucasian males showing neutral facial expression and direct eye gaze were selected from a XXXX database (Peters, Simmons, & Rhodes, 2008). All males wore shorts (above knee) and identical, close-fitting singlets. Thirty-six of these male identities were used as targets and 36 were used as distractors. Targets were randomly allocated to one of 7 study sets, consisting of 3 (4 sets), 6 (2 sets) or 12 (1 set) identities. We included different size study sets to vary task difficulty and allow us to avoid floor and ceiling effects, given the wide age range tested. An additional set of three study items and three test pairs were created for use as practice items.

The original full-length images were cropped and resized to a standardized height. To create face and body stimuli, the head or body was cropped from its original image. Face-only and body-only stimuli were presented at the same size and position as in the original whole-person images. The face-only stimuli were masked using an oval cutaway

¹ Analyses excluding participants who had not lived in Australia or another western country all their lives produced the same results as those presented here.

so that the face and ears were visible but the neck and hair were obscured, to minimize reliance on non-face cues for recognition. The same target-distractor pairs were used in both conditions. Two versions of each stimulus, which varied in lighting and contrast, were created in Photoshop to minimize image matching between study and test. The original images were used in the study phase. Altered images were used in the test phase. These test images were created by brightening the images and altering the color balance so that images were subtly redder and yellower than the originals (see Supplementary Materials for details). Test pairs were therefore always similar in lighting and contrast whereas the study stimuli differed from both the test items in lighting and contrast (see Figure 1). Stimuli were presented using SuperLab Version 4.0 on a MacBook Pro Laptop with 17" matte LCD screen set to 1280 x 800 pixels. Face-only stimuli subtended a visual angle of approximately 1.9° (height) by 1.4° (width) and body-only stimuli approximately 12.3° (height) by 4.5° (width) at a viewing distance of 60cm.

Figure 1. Example stimuli for the body and face tasks.

Procedure

The recognition tasks were designed as a child-friendly Detective Game. Participants were told they had to carefully look at a series of ‘baddies’ (faces or bodies) and then identify those individuals in a two-alternative forced choice ‘line-up’ in order to send them back to jail. Each game was broken into blocks, each of which included a study and test phase. The size of the study sets was initially small (3 items) and increased as the game progressed. Starting with small memory sets ensured that participants, particularly children, were not discouraged when they began each task. Approximately half the participants (14 6-year-olds, 17 10-year-olds, 10 adults) completed the face-only recognition game followed by the body-only game. The remaining participants completed the body-only game followed by the face-only game. A predetermined random order, based on participant number, was used to allocate participants to task order.

Each task consisted of 7 blocks (4 x sets of 3 items, 2 x sets of 6 items and 1 x set of 12 items, completed in that order). Each block consisted of a study phase followed immediately by a test phase. The number of test items was the same as the number of study items. So, for Set Size 3 conditions for example, participants were shown three items to study and then their recognition for these three items was tested using three test-pairs, each of which contained one study item and one distractor. They did this four times. Each study phase was initiated by pressing a space-bar, with stimuli appearing sequentially in the centre of the screen for 3000ms each (1000ms ISI). The test phase followed immediately with pairs (target-distractor) remaining on the screen until response. Adults indicated whether the target or ‘baddy’ was on the left or right side of the screen by pressing labeled keys (‘s’ or ‘l’). Children pointed to the ‘baddy’ and the

experimenter pressed the key on their behalf. No feedback was given after any of the trials and breaks were provided after every block. Targets appeared equally often on the left or right side of the screen. After a response was given the next test pair were shown. Upon completion of all the blocks of one set size participants were told that the task was now going to get harder and they would need to remember more items. Study items and test pairs in each block were displayed in a pre-determined random order that was the same for each participant. The trial order was identical for both face and body conditions. Each task (face task or body task) began with one practice trial, consisting of three study identities followed by one test pair, to familiarize adults and children with the task. The session took approximately 15 to 25 minutes for both adults and children.

Results

We did not have any expectation that memory set size would interact with age or stimulus type and preliminary analyses confirmed that this was the case. Set size exerted a significant main effect but did not interact significantly with the other factors (see Supplementary Materials). We therefore collapsed across the different set sizes and calculated accuracy for each stimulus type (face-only, body-only) as the total percentage of stimuli correctly identified. Four participant's scores were identified as outliers by the SPSS Explore function (identifies scores that are more than 1.5 interquartile ranges outside the interquartile range). One 10-year-old had low outlier scores in both tasks, another 10-year-old was a low outlier only in the face task, a further 10-year-old was a high outlier in the body task and one adult was a low outlier in the face-only task. Scores

from these participants were replaced by the next closest score that was not an outlier².

Assumptions for ANOVA were met with all variables being normally distributed (z-scores for skew and kurtosis < 1.96 , Field, 2013) and no significant differences in error variances (Levene's tests, all $ps > .17$).

Mean accuracy for face-only and body-only conditions for each age group is shown in Figure 2. Recognition of both stimulus types improved with age and children, like adults, identified faces more accurately than bodies. Children's performance was not at adult levels for either faces or bodies. These patterns were confirmed by a two-way mixed-model ANOVA with Stimulus Type (face-only, body-only) as a within-participants factor and Age Group (six, ten, adult) as a between-participants factor. We found a main effect of Stimulus Type, $F(1, 82) = 59.07, p < .001, \eta_p^2 = .42$, with more accurate recognition of faces ($M = 74.0, SD = 14.3$) than bodies ($M = 64.3, SD = 14.0$). There was also a significant effect of Age Group, $F(2, 82) = 74.66, p < .001, \eta_p^2 = .65$. Least Significant Difference (LSD) pairwise comparisons showed that adults ($M = 84.7, SD = 6.8$) performed significantly better than 10-year-olds ($M = 68.7, SD = 8.6$) and 6-year-olds ($M = 57.5, SD = 7.5$) and that 10-year-olds performed significantly better than 6-year-olds (all $ps < .001, ds > 1.36$). Importantly, the interaction between Stimulus Type and Age Group was not significant, $F(2, 82) = 2.20, p = .12, \eta_p^2 = .05$, providing no evidence that body recognition improves less than face recognition during childhood. We also confirmed that face recognition was superior to body recognition in each age

² ANOVA results were the same if the original scores of these participants were retained but the data were significantly skewed. So we report the analyses with the truncated data above.

group [planned LSD pairwise comparisons – 6-year-olds, $t(82) = 3.35$, $p = .001$, $d = 0.70$; 10-year-olds, $t(82) = 6.76$, $p < .001$, $d = 1.31$; adults, $t(82) = 3.61$, $p = .001$, $d = 0.95$].

Figure 2. Mean percentage of stimuli correctly identified for face-only and body-only conditions for children aged six and ten, and adults. Error bars show one standard error either side of the mean.

However, we were concerned that a floor effect for body recognition performance in 6-year-olds may have impacted on the pattern of results. Six-year-olds performed only marginally above chance, $t(27) = 2.03$, $p = .053$, $d = 0.38$, for bodies, whereas performance was significantly above chance (all $ts > 6.13$, $ps < .001$, $ds > 1.15$) and below ceiling (all $ts > 7.5$, $ps < .001$, $ds > 1.60$) for all three age groups in all other conditions. It is therefore possible that these data underestimate the improvement in body recognition between ages 6 and 10. To rule out this possibility we sought to examine

performance uncontaminated by floor effects by taking advantage of the different set-sizes (3, 6 and 12) that were included in the task. Body recognition performance was above floor for 6-year-old participants for the 12 items presented in memory sets of 3, so we calculated the proportion correct for each participant for both bodies and faces at this set size. However, unsurprisingly, adult scores were highly skewed, with over half the participants (12/22) scoring 100%. We therefore restricted this analysis to the two child groups. Performance was significantly above chance ($ts > 3.16$, $ps < .005$, $ds > 0.59$) and below ceiling ($ts > 7.02$, $ps < .001$, $ds > 1.18$) for both 6- and 10-year-old groups for both faces and bodies (see Figure 3). ANOVA³ revealed significant main effects of age group, $F(1, 61) = 8.76$, $p = .004$, $\eta_p^2 = .13$, (6-year-olds $M = 63.2$, $SD = 11.9$; 10-year-olds $M = 73.4$, $SD = 14.8$), and stimulus type, $F(1, 61) = 16.27$, $p < .001$, $\eta_p^2 = .21$, (Faces $M = 73.5$, $SD = 17.5$; Bodies $M = 64.3$, $SD = 16.2$). The interaction between age group and stimulus type was not significant, $F(1, 64) = 1.49$, $p = .227$, $\eta_p^2 = .02$. Therefore, even in the absence of floor or ceiling effects, face recognition and body recognition showed similar improvement between ages 6 and 10.

³ The 10-year-old's face scores showed significant skew and kurtosis (z scores > 1.96), primarily due to two low-scoring participants, though only the lowest of these scores was identified as an outlier. Replacement of both these scores with the next lowest score resulted in acceptable skew and kurtosis, but replacement of only the lowest score did not. ANOVA results for truncated data with acceptable skew and kurtosis were the same as for the raw data so we present analyses using the raw data above.

Figure 3. Mean percentage of stimuli correctly identified in the Set Size 3 trials for face and body conditions for 6 year-old and 10 year-old children. Error bars show one standard error either side of the mean.

Discussion

We found no evidence that body recognition improves less than face recognition during childhood. Both body and face recognition improved significantly between age 6 and adulthood and the size of the improvement with age was similar for both bodies and faces. Children, like adults, showed a face advantage, recognizing faces more accurately than bodies. Importantly, there was no evidence that the size of this advantage changed with age. Children did not perform at adult levels for either faces or bodies, indicating that both body and face recognition continue to improve after age 10. Overall our

findings suggest that body and face recognition skills improve similarly between ages 6 and 10.

The similar improvement we observed for body and face recognition between ages 6 and adulthood could indicate that specialized mechanisms of both body and face perception mature at the same rate. Logical candidates for such mechanisms are holistic coding and norm-based coding because these specialized mechanisms are crucial to face perception (Maurer et al., 2002; Rhodes & Leopold, 2011) and have recently been found to contribute to body perception also (Rhodes et al., 2013; Robbins & Coltheart, 2012a, 2012b). However, this can't be the case because there is little evidence of age-related improvement in the mechanisms of holistic or norm-based coding used for coding face identity. Rather, these mechanisms are both qualitatively present and quantitatively mature early in development (Ferguson, Kulkofsky, Cashon, & Casasola, 2009; Jeffery et al., 2010; Jeffery, Rathbone, Read, & Rhodes, 2013; Jeffery, Read, & Rhodes, 2013; Jeffery et al., 2011; Macchi Cassia, Picozzi, Kuefner, Bricolo, & Turati, 2009; Macchi Cassia, Turati, & Schwarzer, 2011; Turati, Macchi Cassia, Simion, & Leo, 2006). Likewise, Seitz (2002) found that holistic coding of bodies is both present and mature in 8-year-olds.

The apparent maturity of the mechanisms described above suggests that we need to consider other mechanisms that could contribute to the age-related improvement in face and body recognition. There is some evidence that face-space may become more refined during development, as experience with faces accumulates, and that this could contribute to improvements in face recognition (Jeffery et al., 2011; Johnston & Ellis, 1995; Nishimura, Maurer, & Gao, 2009). It is plausible that body-space could similarly

be refined with age. Another aspect of face perception that shows quantitative improvement between ages 6 and 10 is sensitivity to the spatial relations between face parts (Mondloch et al., 2002). It is possible that increasing sensitivity to the spatial relations between body parts with age could also underlie improvement in body recognition.

It is also possible that improvements in more general perceptual and cognitive processes, such as Vernier acuity or attention (Betts, McKay, Maruff, & Anderson, 2006; Skoczenski & Norcia, 2002), could account for the similar age-related improvement in body and face recognition that we observed. This possibility is consistent with evidence that age-related improvements in recognition of objects, such as houses or Labrador dogs, which do not rely on face-specific processes, are similar in size to those for face recognition (Aylward et al., 2005; Crookes & McKone, 2009; McKone et al., 2012; though see Weigelt et al., 2014). Future work is needed to determine if improvements in general perceptual and cognitive processes can account for the age-related improvements in body and face recognition that we observed.

We also found no evidence that body recognition matures before face recognition between ages 6 and 10. Our 10 year-old participants did not perform at adult levels on either task. It remains possible, however, that body recognition could mature earlier than face recognition (but after age 10). Indeed, even face recognition is not mature by early adulthood as evidence suggests that face recognition performance continues to improve until the early thirties (Germine, Duchaine, & Nakayama, 2011; Susilo, Germine, & Duchaine, 2013). It is not yet known if body recognition likewise continues to improve during adulthood. Future research, examining the development of body recognition skills

beyond age 10 will be needed to determine the full developmental trajectory for body recognition and how it relates to the trajectory for face recognition.

Our finding that face and body recognition showed similar improvement with age is interesting given brain-imaging evidence that the Fusiform Body Area (FBA) does not show developmental change during childhood (Peelen et al., 2009) whereas the Fusiform Face Area (FFA) does (e.g., Golarai et al., 2007; Golarai, Liberman, Yoon, & Grill-Spector, 2010). The FBA appears to mature early, showing no change in size or selectivity after age 7, unlike the FFA which increases in size and selectivity into adolescence (Peelen et al., 2009). Moreover, the FBA is 70 percent larger than the FFA in children, whereas in adults both regions are comparable in size (Peelen et al., 2009). Our result indicates that body recognition performance continues to improve despite little change in the size or selectivity of the FBA. One possible explanation is that the FBA, may not be directly involved in body recognition, though it may be involved in representing aspects of body shape that support recognition (Downing & Peelen, 2011; Peelen & Downing, 2007). The FBA is implicated in many other aspects of body perception, such as perception of emotion, body movements and goal-directed actions (Downing & Peelen, 2011; Peelen & Downing, 2007). By contrast the FFA has been strongly linked with face recognition (Grill-Spector, Knouf, & Kanwisher, 2004; Rotshtein, Henson, Treves, Driver, & Dolan, 2005).

Our findings differ from those of Weigelt et al (2014), who found that face memory improved more dramatically than body recognition between ages 5 and 10, whereas we found similar improvement in both face and body memory between ages 6 and 10. Our failure to find a significant interaction between age group and stimulus type

cannot readily be attributed to insufficient power because our samples were larger than those of Weigelt et al (2014). Nor can the lack of a significant interaction be attributed to tasks that were not sensitive to age differences because we found a clear main effect of age. Moreover, when we controlled for floor effects in our youngest group we still failed to find a significant interaction. As noted in the Introduction, our study had several methodological advantages over Weigelt et al (2014). Namely, we used photographic images of both faces and bodies, the face and body photos were of the same individuals, we varied the image characteristics between study and test, and we tested children's memory for each category immediately after study. Moreover, by varying the memory set size we were also able to rule out the influence of floor (or ceiling) effects on the pattern of age-related improvements that we observed, yet maintain the typical difference in the difficulty of recognizing bodies relative to faces. We therefore argue that our results better reflect children's real-world body and face recognition abilities than do those of Weigelt et al (2014).

Finally, we presented faces and bodies at the same size as they appeared in whole-person photographs, thereby preserving their natural size difference. Our faces were presented at a size consistent with the distances at which one attempts to identify individuals in real-world scenarios (approximately 3.7m). This distance falls within the range at which holistic processing is argued to peak, at least for adults (2-10m; McKone, 2009). However, our face stimuli were considerably smaller than the faces used by Weigelt and colleagues (2014). It is possible that there is detailed information in larger images that older children and adults can take advantage of but that younger children cannot. We think that this is unlikely, however, because there is evidence that the

opposite is true. Increasing the size of faces benefits the performance of young children more than it benefits the performance of older children (Lundy, Jackson, & Haaf, 2001).

In summary, we found similar improvement in body and face recognition performance with age. We found no evidence that body recognition skills mature prior to age 10, though it remains an open question whether body and face recognition skills reach maturity at different ages later in development or adulthood. Children, like adults, showed a face advantage, finding bodies more difficult to recognize than faces. Future research should focus on determining why face and body recognition show similar improvement during childhood and whether both continue to improve in tandem beyond age 10. In particular it will be important to determine whether or not improvement on both face and body recognition tasks can be entirely accounted for by improvement in general cognitive and perceptual skills.

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