The Relation Between Facial Recognition Abilities and Attentional Biases Towards Attractive Faces

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Abstract

Previous literature has shown that attractive faces capture the attention of both males and females, with certain studies finding that males are more strongly attracted to attractive female faces. On the other hand, research has also shown inconclusive results when it comes to the relation between facial distinctiveness, attractiveness and people's ability to recognize faces. The current study evaluates participant's facial recognition abilities and then tests whether attentional biases exist among those who have high, or low, facial recognition abilities. Thirty-two participants aged between nineteen and thirty-one years old completed the Benton Facial Recognition test, revised, which evaluated their ability to recognize faces. Participants then completed a visual search paradigm where they were tasked with finding an emotional face in a grouping of neutral faces, and to correctly indicate the present emotion. Inconsistent with previous research, the current study finds that attractive faces are not effective at capturing attention, regardless of sex. The current study also finds that participant's performance in a facial recognition task does not allow for significant predictions of their fixation duration on attractive and unattractive faces.

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1. Introduction

Attentional biases towards attractive faces has been a subject thoroughly studied through the lens of social and environmental psychology, with little research conducted in the domain of visual cognition. The aim of this study is to research the connections between humans' ability to correctly identify faces, and the patterns of attention towards attractive and unattractive faces. The interests of this study highlight, but are not limited to, the effects of age, sex, gaze duration, and facial recognition ability.

1.1. Attractiveness, attentional capture, and attentional adhesion

Prior research indicates that attractive female faces are effective stimuli at capturing the attention of both men and women, and that both sexes overestimate the frequency of appearance of attractive female faces when subjugated to conditions where only minimal attention can be sustained (Maner et al., 2003). The main concept behind the first three studies presented in Maner et al. (2003) was to test if by altering the amount of time a face is visible, or if by altering the presentation type, participants will overestimate or underestimate the presence of attractive faces.

In study one, Maner et al. (2003) modified the presentation type. Faces were either presented one at a time on the screen (serial), or were all presented at once (parallel) in an array consisting of three rows of five photos. Female faces and male faces were presented separately. In study two, Maner et al. (2003) changed the two groups of presentation. Now, all faces would be presented immediately (parallel), but the amount of time that they remained visible differed (4 seconds vs. 40 seconds). After each block of presentation of faces, a questionnaire was filled out by participants to record their estimates of the faces seen.

From the first two studies in Maner et al. (2003), the authors discovered: the overestimation of attractive female faces occurred only in the attention-limiting circumstances (parallel presentation, or 4 second parallel presentation). In the serial condition (attention not limited), estimates of attractive male and female faces did not differ. Importantly, estimates of attractive male faces did not differ in the attention-limited and the attention not limited conditions. Similarly in study two, the presentation time (4 sec. vs. 40 sec.) did not affect the number of estimates of attractive male faces. These results support the hypothesis "female beauty captures the mind" (Maner et al., 2003), in other words both men and women portray a tendency to overestimate the number of attractive female faces presented. Meanwhile male faces, even those that are attractive, are not overestimated, neither by men nor by women. Maner et al. (2003) hypothesis of "opposite-sexed beauty captures the mind" will be discussed below in study four.

While study three was essentially the same methodologically as study one and two, Maner et al. (2003) added a relationship questionnaire at the end of the task. The questionnaire was used to distribute participants into two groups, committed and uncommitted. The researchers found that relationship commitment moderates the tendency to estimate high proportions of attractive women. Among men, uncommitted men overestimated the number of attractive women presented in the attention limiting condition (4 seconds). There was no difference present in the 40 second condition where attention was not limited. In contrast to men, women presented the opposite effect. Study three found that committed women overestimated the number of female targets (only) in the attention limiting condition. These two different patterns among men and women were explained through an evolutionary perspective as being linked to sex differences in reproductive strategy (Maner et al., 2003).

In study four of Maner et al. (2003), participants viewed an array of eight male faces and eight female faces, with half of the faces having average attractiveness, and the other half being above average in attractiveness. Facial expressions were controlled for. This was the first study in the article to employ the usage of an eye tracker. Participants first looked at an array of apples and bananas under the false pretense of doing a color perception task, after this the word “FOCUS” appeared instead of a fixation cross. When the fixation word disappeared, participants naturally looked at the array of faces presented. At the end of this task, participants filled out the SOI, or sociosexual orientation inventory. This tool allows for measuring the tendency of individuals to have casual and uncommitted sexual relationships. The eyetracking results showed the same results as the previous three studies, in addition to, a greater bias for female participants to look at attractive male faces for more than half the time. This adds evidence for the “opposite-sexed beauty captures the mind” hypothesis which was not supported by the data from studies one to three (Maner et al., 2003). When it came to the effect of SOI, the researchers found that unrestricted participants looked more at attractive opposite-sex targets than restricted participants. In terms of relationship commitment, it did not affect male participants' selective attention towards attractive female targets. In contrast, committed women looked less at attractive male faces than uncommitted women. The opposite-sex attention bias found in study four of Maner et al. (2003) was also found in the soon-to-be mentioned study by Leder et al. (2016).

In contrast to studies one through three, but in similarity to study four in Maner et al. (2003), Valuch et al. (2015) found that there is an attentional bias towards females exhibited uniquely by male participants, in other words, male participants exhibited faster saccades to the target when a feminine face was presented, but the opposite was not found for females. In comparison to studies one through three conducted by Maner et al. (2003), Leder et al. (2016) did find that attractive faces are effective at capturing the attention of an opposite-sex participant. Leder et al. (2016) captured 60 photographs of dyads of people (male-male, female-female, female-male) which were used as stimuli. Participants were asked to dress in dark clothing with little distractions (no heavy makeup, jewelry, etc.) and the photographs were taken in a naturalistic setting. During the study, an eye tracker was used to take three measurements, total fixation duration, fixation count, and first fixation duration. In the first block of the experiment, participants viewed each one of the 60 photos for ten seconds each, with no instruction other than to naturally look at the photos. In the second block of the experiment, participants rated the attractiveness of each person in each dyad, and in the third block, participants rated the familiarity of each face in each dyad.

Leder et al. (2016) found correlations that suggest, the higher a face was rated in attractiveness, the longer it was looked at. This relationship between attractiveness and total fixation duration was higher for female faces compared to male faces. Similarly to studies three to five from Maner et al. (2003), Leder et al. (2016) found an opposite sex attraction effect, where participants gazed more at opposite sex faces rather than same sex faces, and this effect was present among both male and female participants. Despite this effect, both men and women still looked more at attractive female faces, and rated female faces as more attractive, compared to male faces. In addition, Leder et al. (2016) found that people in a committed relationship rate faces as more attractive than single individuals, however the relationship between TFD (total fixation duration) and facial attractiveness was higher for single individuals. In other words, single individuals fixated for longer upon more attractive faces, but did not rate them as attractive as committed individuals in a relationship.

These aforementioned studies suggest that facial attractiveness is an effective stimulus at capturing people's attention and causes long gaze durations. However, not all authors agree with this concept. For example, Shimojo et al. (2003) found a phenomenon which they entitled: the gaze cascade effect. In effect, people look at attractive faces for longer durations, and the longer they look at the face, the more they judge the face as attractive.

Attentional adhesion is highlighted in a study conducted by Valuch et al. (2015), where they found that attentional disengagement from attractive faces is slower than from non-attractive faces. This result was found by implementing a gap-saccade task where participants would fixate on a centrally fixated face, and then make a saccade towards a stimulus that appeared in the periphery (a dot). In certain trials the central stimulus (face) would remain visible when the peripheral stimulus appeared (overlap condition), while in other trials the face would disappear as soon as the dot appeared (gap condition). Valuch et al. (2015) found that reaction times were significantly quicker in the gap condition, signifying that attractive faces acted as a distractor, and participants had a harder time looking away. Specifically, male participants had a harder time looking away from attractive female faces. In this first study researchers were also interested if inter-individual differences (specifically eye color) would modulate the effects of attention adhesion, but none were found.

In the same article by Valuch et al. (2015), researchers studied the effects of attractiveness on attentional capture by using a dot probe task. In the new experimental paradigm, the researchers used morphed faces uniquely (whereas in study one, both natural and morphed faces were used). The importance of the usage of morphed and natural faces was not explicitly explained, however, a possible explanation proposed by the authors may be that morphed faces were created to minimize contextual features that would "…attract attention independently of face gender and eye color," (Valuch et al., 2015, pg. 11). The paradigm consisted of a fixation point, and after a certain time there would be an onset of a masculine and a feminine morphed face to the left and the right of the fixation point. The presentation time of the face cues was variable. After the SOA time, a yellow and green box appeared surrounding the two faces, in some trials, the target cue was the yellow box, in others, the green box. Just like in Valuch et al. (2015) first study, male participants rated feminine faces as more attractive than masculine faces, and male participants made faster saccades to the target when a feminine face was present within the target. Once again, eye color (blue vs. brown) did not affect attentional capture.

Another study conducted by Faust et al. (2019) implemented a numerical judgement task to test attentional attraction. Participants were presented with a "basis" number at the bottom of the screen, and two possible target numbers at the top left and right of the screen. Next to each of the two targets, a face was presented. In congruent trials, there was an attractive face located next to the correct target. In incongruent trials, there was an unattractive face located next to the correct target, and for control trials, there was a moderate face located next to the correct target. Participants had to ignore these faces, and to choose the target number which was closest to the basis number within five seconds. For the first experiment, mouse trajectory was tracked, and for the second, eye tracking was implemented.

For both mouse and eye tracking measurements, the researchers found that the incongruent condition elicited longer response times compared to the congruent condition. For eye tracking results: for faces placed next to the correct target number, participants fixated more times and for longer on attractive faces compared to moderate faces, and the same pattern was found for unattractive and moderate faces; however, there was no difference in fixation amount and time between attractive and unattractive faces. For faces placed next to the incorrect target number, participants fixated more and for longer on attractive faces compared to unattractive faces, and participants fixated for more on both of these faces compared to moderate faces. For mouse tracking results: for the measurement of maximum deviation, incongruent trials deviated more than congruent trials. There was no difference between congruent and control trials. This exact same pattern was found for the measurement of distance travelled (more distance was travelled in incongruent trials), and for reaction time (incongruent trials took more time to complete). While Faust et al. (2019) study showed that attentional attraction can also be measured in other modalities aside from eye tracking, they did not measure the possible effects and interactions of participant's sex and the sex of the face cues.

Aharon et al. (2001) provided a biological explanation in order to try and explain the phenomenon of attractiveness and attentional capture, specifically male behavior. Aharon et al. (2001) noted that heterosexual male subjects rated beautiful male faces as very attractive but did not expend their effort to increase the viewing time of these faces, and that when males look at attractive female faces, there is a stimulation and activation of reward circuitry in the brain, notably the NAc, SLEA, amygdala, GOb, and VT. It is important to note that no extrinsic motivation was provided during the duration of the experiment, and that there were no female participants in the study.

Maner et al. (2007) conducted three studies on attentional adhesion; only two of the three will be mentioned for brevity and pertinence. In study one, Maner et al. (2007) established a dot probe visual cueing task to test participant's emotional / physiological state in relation to attentional adhesion towards faces of varying levels of attractiveness. In one condition, the sexual arousing priming condition, participants wrote down and visualized four to five instances of such experiences. In the happiness priming condition, the same task was done but with the concept of happiness in mind instead. Participants then filled out the BMIS (brief mood introspection scale) and the SOI. After completing both questionnaires, the participants completed the dot probe visual cueing task. First, a fixation cross appeared, afterwards, a target face appeared in one of four quadrants on the screen. After the target photo disappeared, a circle or square appeared either in the same quadrant (filler condition) or a different quadrant (attentional shift condition). The task of the participants was to categorize as quickly as possible if the shape which appeared was a circle or a square. Researchers found that there was no difference in attentional adhesion towards opposite sex targets among restricted and unrestricted individuals in the happiness priming condition. Meanwhile in the sexual arousing priming condition, unrestricted individuals exhibited a larger effect of attentional adhesion towards opposite sex targets; restricted individuals in this condition showed a diminished effect.

Study three of Maner et al. (2007) used a guided imagery task to once again test the influence of an emotional / physiological activation and its effects on attentional adhesion towards attractive faces. Participants in the experimental condition (jealousy) were to imagine a scenario where they found out that their partner is being unfaithful, and to write down how that would make them feel. Participants in the control condition (anxiety) were to do the same task but with the imaginary scenario of failing an exam. Participants completed the same dot probe visual cueing task, and also a questionnaire to evaluate their level of jealousy (multidimensional jealousy scale). This study evaluated participant's intrasexual vigilance, or in other words, how vigilant participants are of people from the same sex. Maner et al. (2007) found that for people with low intrasexual vigilance, being jealous did not change the amount of attentional adhesion towards attractive same-sex targets, meanwhile, for people with high intrasexual vigilance, being jealous increased the effects of attentional adhesion towards attractive same-sex targets.

1.2 Attractiveness as a distractor

Attractive faces are also shown to be effective distractors, at least when it comes to tasks involving spatial attention (Sui & Liu, 2009). Sui and Liu (2009) presented a fixation cross with two empty boxes to the left and right. After a short period of time, the fixation cross was replaced by a directional cue, which appeared briefly, and then disappeared to be once again replaced by a fixation cross. Shortly thereafter, one of the boxes disappeared and was replaced by a face (attractive or unattractive), while at the same time, the box that remained was filled in with plus signs and a capital letter "T" in the middle. The task of the participants was to identify if the letter "T" was inverted, or in the correct orientation.

Experiment one found that in the valid cue condition (directional cue points to target), attractive faces served as effective distractors by increasing the response time of participants. Sui and Liu (2009) explain the lack of effect of facial attractiveness in the invalid cue condition (directional cue points opposite of target) by the fact that participants were most likely already looking at the face in the invalid condition. They suggest that the effect of facial attractiveness could be linked to a spatial attentional shift which occurs in the valid condition. Experiment two found that the effects of facial attractiveness persisted even when SOA was reduced, but only when the faces were presented in the left visual field. Sui and Liu (2009) explain this is due to facial attractiveness being processed by the right cerebral hemisphere. Experiment three confirmed that the effect of facial attractiveness is not affected by foveal fixation.

Facial attractiveness can also be modulated by exogenous variables. Störmer and Alvarez (2016) found that exogenous attentional cues can increase the perceived facial attractiveness of stimuli by effectively increasing the level of local contrast around the eyes. When it comes to attractiveness independent of sex, people tend to look at attractive photos more than at unattractive photos (Silva et al., 2016). Attractive faces can also impact people's memory when it comes to recognizing faces. Attractive photos cause more false recognitions than unattractive photos (Silva et al., 2016; Wickham & Morris, 2003). Facial attractiveness can impact recognizability, and the mere action of allocation of attention does not explain why participants who look more at attractive photos have a harder time recognizing unattractive photos (Silva et al., 2016).

1.3 Unconscious and automatic processing of attractiveness

Some studies show that attention allocation is not necessary to process facial attractiveness. For example, Hung et al. (2016) states that attractive faces are treated in a pre-conscious manner and that attractive faces can serve as distractors when being used as unconscious primers. This further supports the study of Sui and Liu (2009) which found that attractive faces are effective conscious distractors. In regard to the change of treatment from pre-conscious to conscious, attractive faces have the advantage over unattractive faces with shorter suppression time and lower visibility threshold, meaning that attractive faces were processed consciously faster, and they were able to be detected with lower contrast levels (Hung et al., 2016). Suppression was induced by the researchers by implementing continuous flash suppression of Mondrian cubes to the dominant eye, which ensured that identification and visibility of the face presented in the non-dominant eye was not possible. Hung (2016) replicates the finding of the disadvantage of male faces which was also found in Maner (2003). The disadvantage is explained by the finding that male faces had lower attractive ratings and shorter suppression time, and unattractive male faces had higher visibility thresholds (Hung et al., 2016).

The processing of faces is considered an automatic process; Nakamura and Kawabata (2014) found that people involuntarily evaluate attractiveness of female target faces in a dtRSVP stream, with their temporal attention adhering to attractive faces. Essentially, the participants' task was to correctly identify two female faces presented in the rapid serial visual presentation task, and the researchers found that when the second target face (T2) occurred soon after an attractive T1, there was an impairment in participants' abilities to correctly identify the face. In contrast, when T2 appeared later after T1, the attractiveness of T1 served as a facilitator for correctly identifying T2.

There is also bioelectrical evidence when it comes to processing attractive and unattractive faces. van Hoof et al. (2011) found that the P2 wave amplitude is larger during presentation of either an attractive or an unattractive face, whereas the presentation of an average attractive face resulted in a decreased P2 wave amplitude. This suggests that more attention resources are allocated to treating faces that are on either end of the attractiveness spectrum (van Hoof et al., 2011). Both men and women exhibited this same P2 wave activity, however the difference appeared later during the slow wave (200-650 ms after stimulus presentation) where the amplitude was more positive for attractive faces than for unattractive faces, and where the slow wave was more positive in males when viewing attractive female faces. This opposite-sex effect was not observed in females (van Hoof et al., 2011).

1.4 Age and evaluating attractiveness

The effects of age and attractiveness have also been extensively researched. Older adults have a tendency to rate faces as more attractive than young adults (Ebner, 2018; Ebner, 2008; He et al., 2021). Young faces receive higher attractiveness ratings than middle aged and old faces, with young being more attractive than middle aged, and middle aged more attractive than old faces. (Ebner, 2018; He et al., 2021). Young adults gave higher attractiveness ratings to young adult faces (Ebner, 2018; Foos & Clark, 2011; He et al., 2021). Old female faces are seen as less attractive compared to old male faces (Ebner, 2018; He et al., 2021). Middle aged adults rated young and middle-aged faces as more attractive than old faces (Foos & Clark, 2011; He et al., 2021).

1.5 Facial recognition, distinctiveness, and attractiveness

The relation (or lack-thereof) between facial distinctiveness and facial attractiveness is a contentious topic amongst authors. Nakamura and Kawabata (2014) highlight the importance of facial distinctiveness compared to facial attractiveness. In their study, they found that facial distinctiveness did not contribute to the effects of temporal attention. One important study cited by the authors is Carbon et al. (2010), which studied patients with congenital prosopagnosia (cPA) and their abilities in evaluating facial attractiveness and distinctiveness. Carbon et al. (2010) found that cPA participants showed a clear discrimination between attractiveness and distinctiveness, insofar as patients were not able to discriminate facial distinctiveness but were able to evaluate attractiveness. These results suggest a possible separation of these mechanisms during the perceptual phase of face processing. Wickham and

Morris (2003) did not find any relation between participant's ability to recognize faces and the attractiveness of said faces.

Sarno and Alley (1997) also found no correlation between a person's recognition of targets and the target face's attractiveness. However, when it comes to distinctiveness, Sarno and Alley (1997) found that the more distinctive a face is, the more easily it is recognized (more hits, or correct recognition). When the predictor attractiveness is added to the model with the other predictor (distinctiveness), the model no longer predicts recognition performance in a significant manner. Sarno and Alley (1997) also found that confidence is positively correlated with recognition performance.

One problem is that Sarno and Alley (1997) do not provide an operational definition for "distinctiveness". In their methodology, students rated distinctiveness on a nine-point Likert scale (9 = highly distinctive) for faces presented in pairs. The authors only gave this definition to distinctiveness: "Unique, unusual, or atypical appearance for its age and in relation to the other faces in the set," (Sarno & Alley, 1997, p. 85). This terminological problem persists in other areas as well. Sarno and Alley (1997) state that they found a non-significant, negative relationship between facial attractiveness and memorability, in that as facial attractiveness increases, recognizability decreases. This is explained by the authors by the idea that less attractive faces are atypical / distinctive. It is not clear what memorability is, but it can be assumed from the explanation that memorability is the same as recognizability.

In contrast to Sarno and Alley (1997), Malloy et al. (2021) found a positive relationship for facial recognition and facial attractiveness. In other words, as attractiveness increases, so does facial recognition performance. Despite these results, Malloy et al. (2021) urge caution of the interpretation of their data and suggest that methodology might play a large role in their results. This is an important point which will also be highlighted further on in the present study, as methodology was also a concern in the present study.

In study five of Maner et al. (2003), 60 photographs were used as stimuli. Participants in the study watched one of three different clips and were told to empathize with the people in the video clip. Participants were then presented with one of four sets of photographs. After viewing the photographs, participants watched a short distractor video and then completed a phase of recognition of the photographs. Participants rated on a Likert scale from one to ten (with ten being completely sure I saw) their confidence in seeing each photograph. At the end, participants completed the SOI once again. SOI did not affect recognition of photographs. Attractive male faces were less memorable than attractive female faces. Attractive male faces were recognized less than average male faces. Attractive female faces were recognized better than average female faces. Overall, participants were better at recognizing female faces compared to male faces, with male faces evoking more false recognitions. In conclusion, recognition memory is better for attractive female faces compared to attractive male faces. These results also support the studies of Silva et al. (2016) and Wickham and Morris (2003) which were mentioned in the introduction. This bias of facial recognition may have also played a role in the results found in the BFRT-r task in the present study.

1.6 Importance of facial features

Prior to measuring possible relations between facial recognition abilities and attractive faces, it is important to better understand the subjacent mechanisms as to how people identify and recognize faces. While multiple models exist, one in particular is focused on the importance of facial characteristics. Abudarham and Yovel (2016) began the creation of a method to find which facial features are critical and non-critical when it comes to identifying faces. Abudarham and Yovel (2016) first established a face space following the face space theory, proposed by Valentine (1991, 2001), where,

> "…faces are represented in a multidimensional space in which each dimension corresponds to a feature in the face… each face is represented by a point in space, or a feature vector… each of the vector values indicates the magnitude of a feature on its unique scale. Distance between feature vectors ("face space distances") correspond to perceptual differences between faces" (Abudarham & Yovel, 2016).

Abudarham and Yovel (2016) then established two different levels, high perceptual sensitivity (PS), and low perceptual sensitivity. Facial features categorized under high PS have a high perceptual distance (between faces) when modified (i.e. faces seem more different), and low PS has a low perceptual distance between faces (i.e. faces seem more similar). By modifying different facial features, Abudarham and Yovel (2016) measured which modifications of which characteristics caused the greatest perceptual difference between faces.

Why are some facial features more important than others? This question is answered by Abudarham and Yovel (2016) by measuring different viewing angles and conditions. Abudarham and Yovel (2016) conclude that high PS facial features are view-invariant, whereas low PS facial features are view-variant. This means that high PS facial features are less likely to change when the viewing condition (ex. pose, illumination, expression) of a face is changed, and thus less likely to impede facial identification and recognition.

One important thing to note is that since variation among facial characteristics differs among different races (specifically hair color), the tools established in Abudarham and Yovel

(2016) are only applicable for Caucasian face models, as those were the ones used in the experiments.

Abudarham et al. (2019) continue to further evaluate low and high PS. In their first study the authors find that "… high-PS faces are critical for familiar face matching," (Abudarham et al., 2019, pg. 77). In study two, the authors confirm the importance of high PS facial features in facial recognition (where memory is involved). High PS faces are also important in unfamiliar face matching and recognition. So, both processes (identification and recognition) use the same critical features. For familiar face recognition, the feature of hair is important (for Caucasian faces). No matter if hair is modified first or last (compared to other facial features), it will significantly decrease the recognition rate of the familiar face (Abudarham et al., 2019).

The five critical (high PS) facial features (for Caucasian faces) are lip thickness, hair, eye color, eye shape and eyebrows. The five non-critical (low PS) facial features are the mouth, eye distance, face proportion, skin color, and the nose (Abudarham & Yovel, 2016; Abudarham et al., 2019; Abudarham et al., 2021).

Abudarham et al. (2021) investigated whether super recognizers (SR) and developmental prosopagnosics (DP) rely on the same facial features for face identification and recognition. The same critical (high PS) facial features are used by SR's as by normal people for facial recognition of familiar faces. SR's were less affected when two or three of the high PS characteristics were modified, and they showed much better recognition capabilities when non-critical (low PS) facial features were modified. Changing four to five of the high PS characteristics rendered SR's on the same level as the control (normal recognition), while changing four to five low PS features still permitted for SR's to have better performance than controls.

To test DP's, a facial identification task was proposed (because recognition is altered among DP's). Hair was also not a facial feature which was tested among the DPs, because DP's tend to use hair as an indicator for facial recognition (Adams et al., 2019; Abudarham et al., 2021). Alongside the DP's, SR's and controls also completed this task. There was no difference between SR's, DP's and controls for facial identification tasks, only confidence differed among SR's and DP's, with DP's being less confident. In conclusion, controls (normal recognizers), SR's and DP's all used the same critical and non-critical facial features to make their decisions (Abudarham et al., 2021).

When evaluating facial attractiveness, people also use many of these same criteria, both critical and non-critical. Zhang et al. (2017) conducted a study where both male and female participants rated attractiveness of female faces. The participants and the stimuli used in this study were all of Asian origin. Zhang et al. (2017) found that fixation duration was longer for the nose regions than for the eye and mouth regions. The number of fixations was also greater on the nose than on the eyes and mouth, and that there was no difference between the eyes and mouth. Male participants made more fixations than females did, and participants first looked at the eye and mouth region, and then transferred their visual attention towards the nose. (Zhang et al., 2017). These results are interesting because it seems that the nose is a more salient facial feature for evaluating attractiveness of female faces, although the nose is a low PS facial feature. (Abudarham & Yovel, 2016; Abudarham et al., 2019; Abudarham et al., 2021). However, both the eye and mouth region were also looked at, and both of those regions fall under the high PS category. (Abudarham & Yovel, 2016; Abudarham et al., 2019; Abudarham et al., 2021). One possible problem is that Zhang et al. (2017) solely examined Asian faces, and so this study cannot be compared with those done by Abudarham and Yovel (2016), Abudarham et al. (2019) and Abudarham et al. (2021), due to these studies focusing solely on Caucasian face models. Zhang et al. (2017) also cite a possible regional east Asian bias towards the nose region, due to social customs where it is rude to have direct and/or excessive eye contact.

Zhao et al. (2019) conducted a study where they used machine learning to evaluate the attractiveness of 300 East Asian female faces. Factors such as eye size, proportion of iris to the eye, eyebrow curvature, length, width and area, as well as face shape were all measured. Faces that received higher attractiveness ratings had either “high-bending eyebrows with small eyes and round face or low-bending eyebrows with large eyes and longer face,” (Zhao et al., 2019, pg. 10). Once again, high PS facial features such as eyes and eyebrows which are critical for facial recognition and identification, are also looked at to evaluate attractiveness.

Gründl et al. (2011) conducted an experiment where participants measured the attractiveness of the eye area of females. Gründl et al. (2011) found that there was no difference between different iris colors and the attractiveness ratings, although participants did mention that blue colored iris have more positive aspects, which may suggest a positive bias towards blue colored eyes. Eye color is a high PS (critical) facial feature for facial recognition and identification. (Abudarham & Yovel, 2016; Abudarham et al., 2019; Abudarham et al., 2021).

Baudouin and Tiberghien (2004) conducted an experiment where male participants rated the attractiveness of female faces. The authors found that the closer a face was to the average, the more attractive it was rated. The averageness of specific facial features also differed in importance for attractiveness ratings. When facial features such as the eyes, mouth and nose moved farther away from the average, the less attractive the face was seen. These movements mostly occurred on the Y-axis. Baudouin and Tiberghien (2004) also found that different facial characteristics had positive and negative correlations with attractiveness. Characteristics with positive correlations included: “eye width, mouth and upper lip thickness, and cheekbone prominence and height,” while negative correlations included, “brow thickness, and width and area of the nose and chin,” (Baudouin & Tiberghien, 2004, pg. 325). Schmid et al. (2008) found that nose, mouth, and upper lip symmetry are important for both male and female participants when rating the attractiveness of male and female faces.

2. Hypotheses and Objectives

By reviewing the literature, we expect to find an attentional bias exhibited by both males and females towards attractive female faces. It is also likely that this attentional bias will be stronger among male participants. Specifically, we expect to find longer dwell time on attractive faces. The present study also measures participant’s facial recognition ability, as the aim is to test if facial recognition ability influences gaze patterns toward attractive faces. Based on pre-existing literature concerning facial distinctiveness, attractiveness and recognition, it is not fully clear what to expect. We predict that individuals who portray a greater ability to recognize faces will be more influenced by facial attractiveness, which is to say that these individuals will portray a strong attentional bias towards attractive faces. We also predict that individuals who portray a lesser ability to recognize faces will be less influenced by facial attractiveness. These two correlations are predicted by the fact that similar specific facial characteristics are visually processed when identifying and recognizing faces, as well as when evaluating facial attractiveness.

In order to test these hypotheses, participants will first take a Benton Facial Recognition (revised) test in order to obtain a score. The score from this facial recognition test will allow inter-participant comparisons of facial recognition ability. Afterwards, participants will participate in the visual search paradigm, where they will be tasked with conducting a visual search of a stimulus and then making a decision. The visual search paradigm task is of no importance other than to measure the gaze durations of each participant to each face (stimuli). Participants are not informed of the actual reason for effectuating the visual search paradigm. These two tests will allow us to draw conclusions to the hypotheses by using data such as gaze duration, facial recognition ability, sex and level of attractiveness of stimuli.

3. Method

3.1 Participants

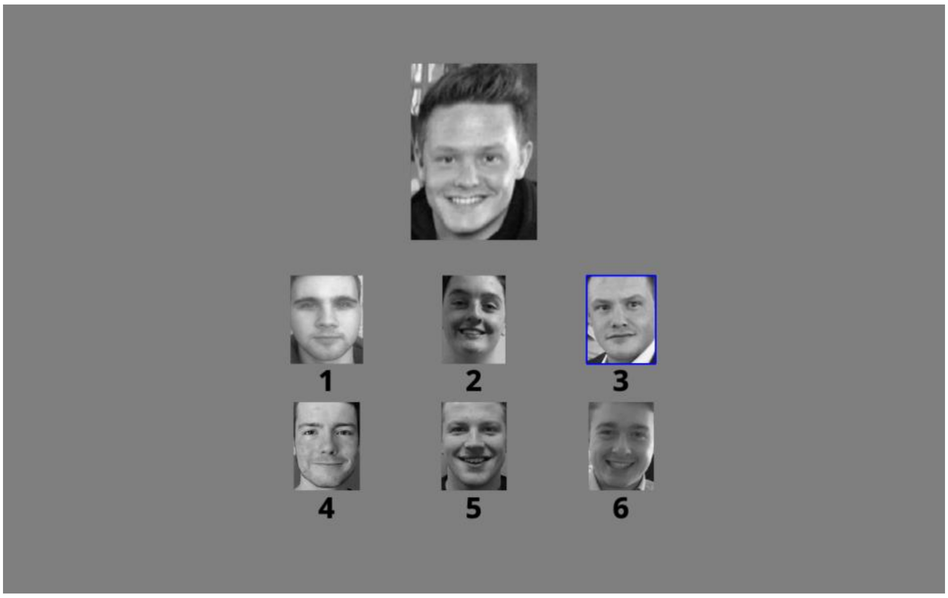
A total of 52 participants participated in the study; 6 participants were used as pilot participants and their data was not included in the analysis, and the data of 14 more participants were removed to due missing data, experimental errors, and age. 32 participants (16 males) were retained in the experiment. Age was controlled for with all participants being between the ages of 19 and 31 *(M=20.758, SD=1.640)*. This age group is taken from the FACES database and is considered “young” (Ebner et al., 2010). All participants provided written consent to participate in the study in exchange for class credit. Participants also verbally provided information regarding their age, visual acuity, and color vision.

3.2 Procedure and Stimuli

The first part of the experiment consisted of participants doing the BFRT-r (Benton Facial Recognition Test, revised) on the Dell PC optiplex 7040 computer. The BFRT-r measures the performance of a participant’s ability to recognize faces (Murray et al., 2021). The BFRT-r was created using PsychoPy version 2022.2.5 (see figure 1). The stimuli were displayed on a 22.5-inch LCD monitor (VIEWPixx Light, VPixx Technologies Inc., Saint-Bruno, Canada). The display frequency was 100 Hz and the pixel resolution was 1,920 × 1,200 pixels. The computer screen was located at a distance of 66cm from the participant. Participants used a mouse and keyboard to respond during the test. Participants used the mouse to select their answers, and to progress to the next trial, the spacebar was pressed. The participant was able to change their answers during a trial, and the participant had in infinite amount of time to complete the task. The task of the participants in the BFRT-r was to correctly choose either one or three faces that match the target face. The target face is presented in the upper portion of the screen, with six choices located below the target face. All faces are presented in black and white images, with different expressions and angles. There are a total of 22 trials in the task; for the first six trials, there is only one correct answer per trial. For trials seven to twenty-two, there are three correct answers per trial. The inter-stimulus interval (ISI) was set to 80 ms between each trial. The total amount of points that can be gained by the participant is 54. The participant is not provided feedback of their performance during or after the task. All stimuli were taken from the open repository provided by Murray et al. (2021). This task can be shared with other researchers upon request.

Figure 1

Image of a trial from the BFRT-r, first section, with only one correct answer possible

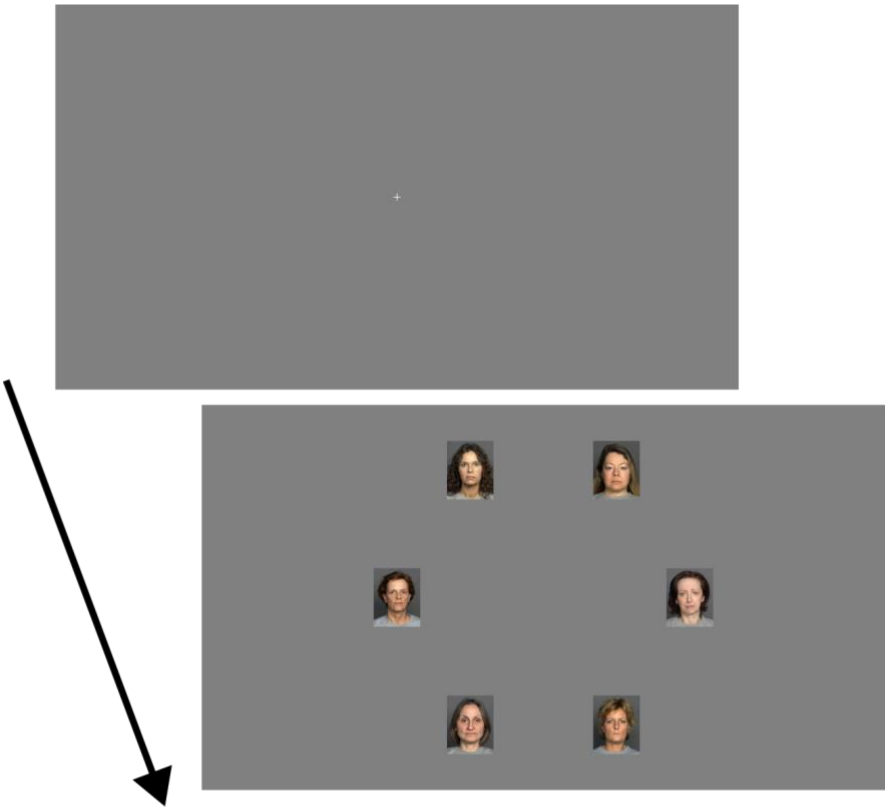


The second part of the experiment is the visual search paradigm. The stimuli were displayed on a 22.5-inch LCD monitor (VIEWPixx Light, VPixx Technologies Inc., Saint-Bruno, Canada). The display frequency was 100 Hz and the pixel resolution was 1,920 × 1,200 pixels. Head position was stabilized with a chin/forehead rest at a viewing distance of 66 cm. Responses were collected on a RESPONSEPixx Handheld 5-button response box (VPixx Technologies Inc., Saint-Bruno, Canada), which had four buttons arranged in a diamond shape and one button in the center. The desktop-mounted EyeLink1000 (SR Research, Ontario, Canada) was used to record eye-movements at a sampling rate of 1000 Hz. To detect saccades, we set the EyeLink1000 to the standard saccade criteria for cognitive research (i.e., velocity of 30°/s and acceleration of 8000°/sec^2).

The visual search paradigm consisted of six faces presented in a circular formation (see figure 2). Each image was shown at 10° from the fixation cross with equal distances between the images (60° of rotation). Two images were on horizontal meridian. The images were drawn from the FACES database (Ebner et al., 2010). For each search display, the faces had the same sex and age group. There were male and female faces in the young, middle-aged and old age group. All but one face had a neutral face, and the task of the participants was to find the one face that had a non-neutral expression, and then to indicate whether the face expressed sadness or disgust. Prior to commencing the experiment, participants were verbally instructed by the experimenter to complete 30 practice trials. A nine-point calibration and validation of the eye tracker was executed during the first and second blocks of the experiment. Recalibration was executed during cases of excessive head or eye movement.

Figure 2

Visualization of the visual search paradigm



Each trial started with participants looking at a fixation cross located in the middle of the screen. When participants fixated on the cross, the experiment began. Between each trial, a fixation cross appeared to which participants had to fixate upon in order to commence the next trial. The left and right buttons were used to indicate a disgusted face or sad face, respectively (fixed mapping). If the participants did not provide a response within a timeframe of 10 seconds, the participant was provided feedback that they responded too slowly. They were also given feedback after incorrect responses. Passing from one trial to the next was automatically done when participants pressed either the left or right button. The task contained 240 trials separated by a break period after the first 120 trials. Among the six faces presented in each trial, there were 3 faces that were rated as being more attractive than the median face, and the other 3 faces were rated as being less attractive than the median face. This information was not presented to the participants. The sole interest of this paradigm was to observe saccadic eye movement in relation to the attractiveness of the faces presented. The identification of the emotional face was used as a placeholder task and served no further importance in the study.

For both the BFRT-r and the visual search paradigm, data from the participants was automatically recorded after the experiment ended, and the data was stored on the computer in the laboratory. The experiment was conducted at the University of Geneva and approved by the University of Geneva and CUREG (university commission for ethical research in Geneva) with the project number (CUREG-MM-2022-11-159).

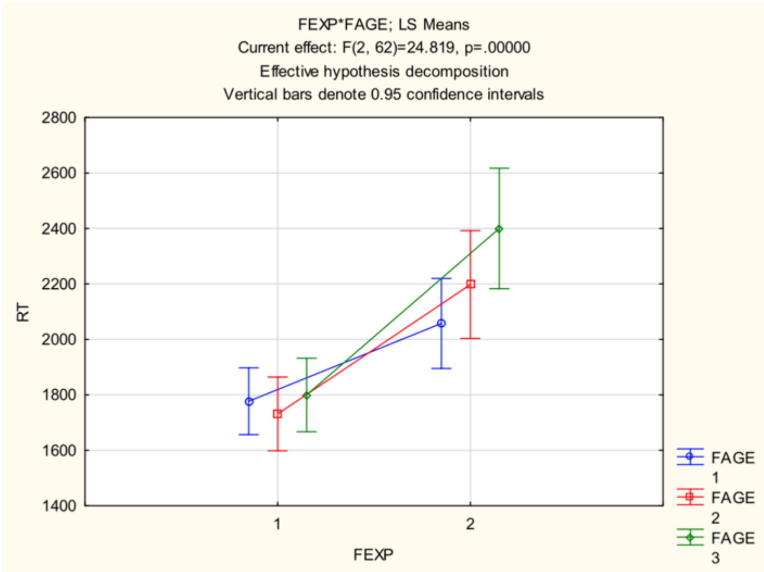
4. Results

4.1 ANOVA

We conducted separate repeated-measures ANOVA on both reaction time and the proportion of decision errors in the visual search paradigm. For reaction time, a main effect was found for stimuli facial expressions (FEXP), $F(1, 31) = 165.153$, $p < .01$, $\eta_p^2 = .84$, where reaction time increased for sad faces compared to disgusted faces. A main effect was also found for stimuli age (FAGE), with reaction time being the slowest for old age faces, and decreasing with age. $F(2, 62) = 40.395$, $p < .01$, $\eta_p^2 = .57$. No main effect was found for stimuli sex (FSEX). $F(1, 31) = 2.293$, $p = .14$, $\eta_p^2 = .07$. A significant interaction between stimuli facial expressions and stimuli age was found (see figure 3). $F(2, 62) = 24.819$, $p < .01$, $\eta^2 = .44$.

Figure 3

Interaction between stimuli facial expression and stimuli age. FEXP (1 = disgust, 2 = sadness), FAGE (1 = young, 2 = middle-aged, 3 = old)

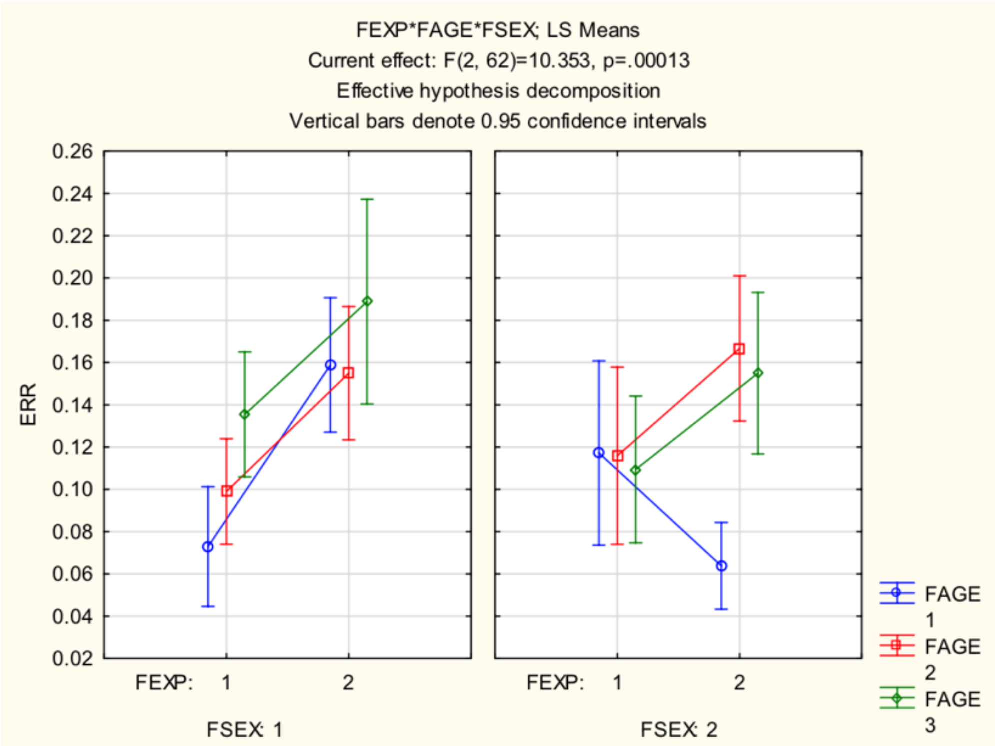


Facial expressions of sadness had increased reaction times compared to disgusted faces, and increased age increased the reaction times. The interaction between stimuli facial expressions and stimuli sex was not significant. $F(1, 31) = 1.188$, $p = .28$, $\eta^2 = .04$. The interaction between stimuli age and stimuli sex was also non-significant. $F(2, 62) = .462$, $p = .63$, $\eta^2 = .01$. Finally, the three-way interaction was also non-significant. $F(2, 62) = 2.807$, $p = .07$, $\eta^2 = .08$. Using the Greenhouse-Geisser correction for violations of sphericity produces identical results.

For the proportion of decision errors, a significant main effect was found for stimuli facial expressions with sad faces causing more errors. $F(1, 31) = 10.131$, $p < .01$, $\eta^2 = .25$. A significant main effect was also found for stimuli age, with errors increasing with age. $F(2, 62) = 11.800$, $p < .01$, $\eta^2 = .28$. No significant main effect was found for stimuli sex. The two-way interaction between stimuli facial expressions and stimuli age was also non-significant. Meanwhile, the interaction between stimuli facial expressions and stimuli sex was significant. The proportion of decision errors increases with increased age of facial stimuli and for sad faces compared to disgusted faces. $F(1, 31) = 10.223$, $p < .01$, $\eta_p^2 = .25$. The two-way interaction between stimuli age and stimuli sex was also significant. The proportion of decisional errors increased with age for male faces, while errors for female faces increased up to middle aged faces, and then slightly decreased for old faces. $F(2, 62) = 3.631$, $p = .03$, $\eta^2 = .10$. The three-way interaction was significant (See figure 4). $F(2, 62) = 10.353$, $p < .01$, $\eta^2 = .25$. For male faces, the proportion of decision errors increased from disgusted to sad faces and increased with facial age. For female faces, the same interaction was found, except for one outlier where the proportion of decisional errors decreased for sad young faces. Once again, using the Greenhouse-Geisser correction method provided the same results.

Figure 4

Interaction between stimuli facial expression, stimuli age, and stimuli sex. FSEX (1 = male, 2 = female), FAGE (1 = young, 2 = middle-aged, 3 = old), FEXP (1 = disgust, 2 = sadness)

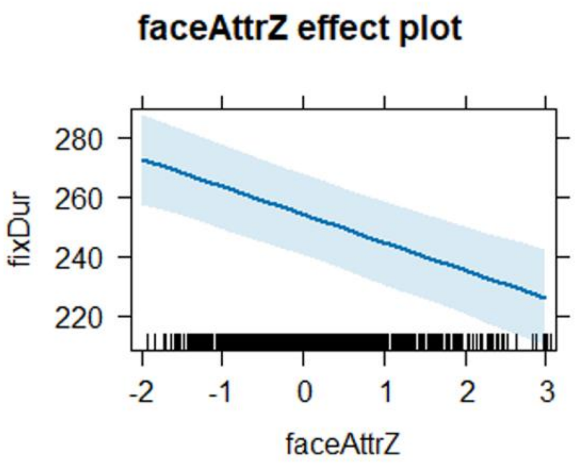


4.2 Mixed linear model

A mixed linear model was used to further evaluate the data. The mixed linear model evaluated multiple items, including but not limited to: duration of eye fixations on non-target faces, duration of eye fixations in relation to the position of the face on the screen, and the duration of eye fixations in relation to the attractiveness of the face and sex of the participant. The model used is: *fixDur ~ faceAttrZ + faceAttrZ*subjSexFact + faceSexFact*faceAgeFact + posFact + (1|subjFact) + (1|subjFact:faceSexFact)+ (1|subjFact:faceAgeFact)+ (faceAttrZ-1|subjFact)*. By completing a type III ANOVA with Satterthwaite's method, a significant main effect was found for Z-transformed stimuli facial attractiveness (faceAttrZ), $F(1, 40.9) = 38.83$, $p < .01$, showing that fixation duration decreased when facial stimuli attractiveness increased (see figure 5).

Figure 5

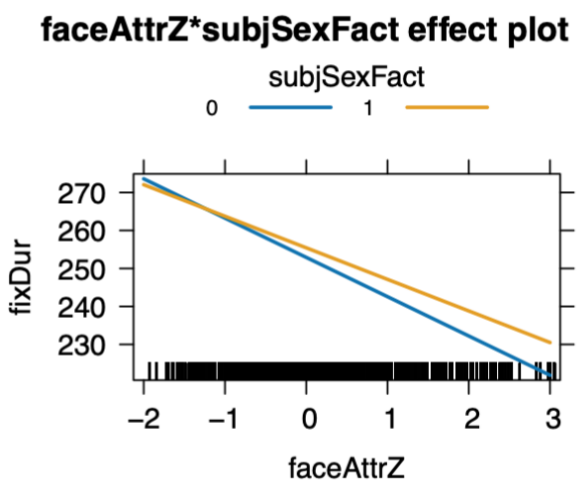
Negative correlation between fixation duration and the level of face attractiveness



Adding in the variable of participant sex (subjSexFact) showed that there was no significant difference between male and female participants in terms of fixation duration on either attractive or unattractive faces (see figure 6).

Figure 6

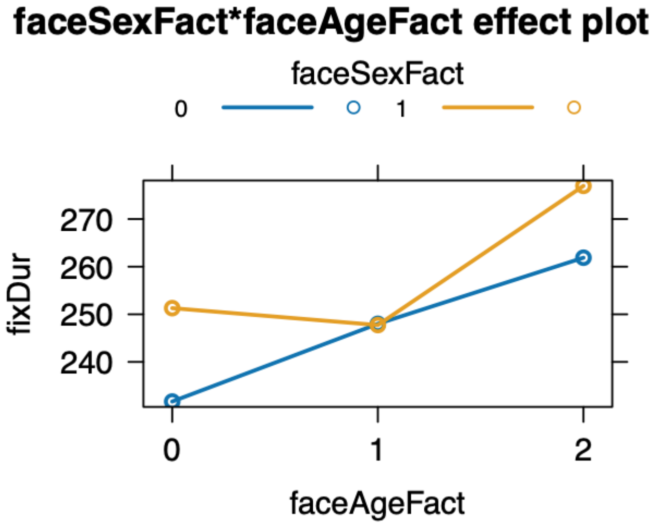
Insignificant difference between participant sex for negative correlation between fixation duration and level of facial attractiveness (0 = male, 1 = female)



A significant main effect was found for stimuli sex (faceSexFact). $F(1, 32) = 11.07$, $p < .01$. A significant main effect was found for stimuli age (faceAgeFact). $F(2, 64.4) = 33.37$, $p < .01$. A significant main effect was also found for the position of the face (posFact). $F(5, 30431.7) = 14.38$, $p < .01$. A significant interaction was found between stimuli age, stimuli sex, and the duration of fixation (See figure 7). $F(2, 30410.4) = 13.26$, $p < .01$. Young female faces were fixated on for longer durations than young male faces. Middle aged faces were fixated on for equal durations, irrespective of the sex of the face. For old faces, old female faces were fixated on for longer durations than old male faces.

Figure 7

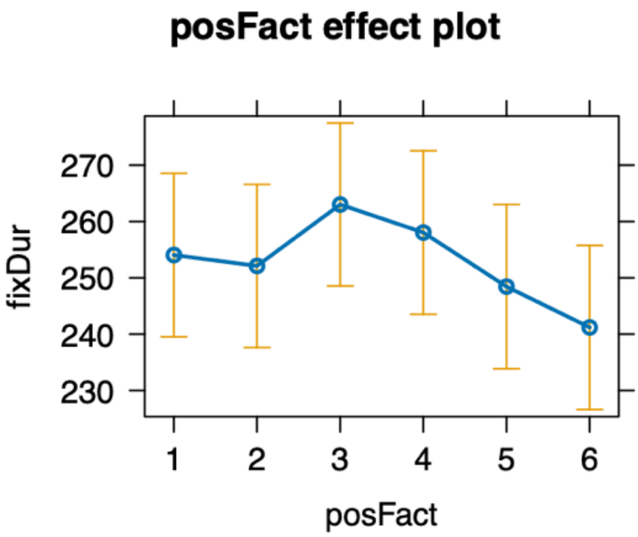
Interaction between stimuli sex, stimuli age, and fixation duration (faceSexFact: 0 = male, 1 = female; faceAgeFact: 0 = young, 1 = middle aged, 2 = old)



Fixation duration also varied depending on where the faces were presented. Faces in position 3 (top left) were fixated for the longest durations, while faces in position 6 (bottom right) were fixated on for the least amount of time (see figure 8).

Figure 8

The relation between fixation duration and the position of facial stimuli (1 = right, 2 = top right, 3 = top left, 4 = left, 5 = bottom left, 6 = bottom right)



4.3 Spearman correlations

We also evaluated three different Spearman correlations. The first correlation was between the variables BENTON and SLOPE. BENTON was the score according to the BFRT-r questionnaire, and SLOPE was the slope of fixation duration and Z-transformed attractiveness which was found by creating a mixed linear model. No significant effect was found relating participant's performance on the BFRT-r to their tendencies to fixate on unattractive faces *(r = -.15)*. The second correlation was BENTON x Mean_RT, which evaluated participants performance on the BFRT-r to the global reaction time. No significant effect was found *(r = .17)*. The last correlation was Mean_RT x Mean_ERR which evaluated global reaction time to the rate of errors. Once again, no significant effect was found *(r = -.25)*.

5. Discussion

The present study evaluated attentional biases toward faces based on sex and attractiveness, and the link between these patterns and people's facial recognition abilities. In contrast to previous studies, this present study found a negative correlation between gaze duration and attractiveness, wherein the more a face was attractive, the shorter the gaze duration. In contrast to the results that we found, Leder et al. (2016) found the opposite in regards to gaze duration, with participants gazing longer at more attractive faces. Unlike our initial findings that attractiveness repels, Valuch et al. (2015) found that attractiveness attracts, but instead of gaze duration, they measured saccadic speed, with faster saccades being executed towards more attractive faces.

Contrary to our main hypothesis, we found that facial recognition ability does not significantly predict participant's fixation patterns towards attractive or unattractive faces. This result replicates the results found in Wickham and Morris (2003) and Sarno and Alley (1997) which both found no correlation between participant's recognition ability and facial attractiveness. This result goes against the recent study of Malloy et al. (2021) where they found a positive effect of facial recognition and facial attractiveness. If this study will be redone in the future, it may be of interest to choose a different facial recognition test (ex. Cambridge Face Perception Test) or to use multiple different ones in order to test and see if there is a possible effect of facial recognition tests. Since the current study was not interested in participant's memory abilities, we did not use a test such as the Cambridge Facial Memory Test. The current study also did not take into account the aspect of facial distinctiveness. This may also be an important aspect to add in the future as the above studies were also interested in it, however there is neuropsychological evidence that suggests otherwise, in which the processing of facial distinctiveness and facial attractiveness are two different processes (Carbon et al., 2010).

As for the effects of stimuli facial attractiveness, stimuli sex, and participant sex on fixation duration, it is very surprising that no effect of participant sex was found for patterns of fixation duration on attractive faces. As highlighted in various studies in the introduction (Maner et al., 2003; Maner et al., 2007; Valuch et al., 2015; Leder et al., 2016), it was safe to predict that at the very least, we would see an effect of the hypothesis "female beauty captured the mind", if not even "opposite-sexed beauty captures the mind". In contrast to previous studies, the current study found no significant difference between males and females and their tendencies to fixate longer on either attractive female faces, or on attractive faces of the opposite sex. One possible explanation might be that each trial contained only male faces, or only female faces. When redoing this experiment, it would be interesting to see if the results changed if stimuli sex was mixed for each trial.

The present study used stimuli that were already rated and validated, and participants in the current study did not rate facial attractiveness of the stimuli used. All studies mentioned in the introduction that measured the effects of age on attractiveness had participants who had rated the stimuli used in a separate task. The present experiment also had a controlled age range of participants (19-31 years old) so in any case it would not be possible to draw conclusions based on three age groups (young, middle aged, and old). Despite this, the present study found that fixation duration was greater for female faces of all ages, except for middle aged faces, where fixation duration was equal for male and female faces.

The methodology used in the present study was not perfect. In the visual search paradigm, not all participants looked at all six of the faces presented. Originally this paradigm included five faces of average attractiveness and one face of above average attractiveness. To combat the issue of not all stimuli being looked at, the face stimuli were changed to three below average and three above average faces. If this study was to be redone, it might be wise to change the methodology of the visual search paradigm. One possible option is: participants view an array of six neutral faces that lasts ten seconds, afterwards a new array appears with new faces. This continues until the participant has seen all the stimuli used from the FACES database in the present study. The instructions given to the participant is to just "naturally observe the faces presented". After this is complete, the visual search paradigm can be started. After the end of the visual search paradigm, participants will view one face presented at a time, and rate on a Likert scale from one to seven the attractiveness, with seven being highly attractive. This revised methodology may also combat the problematic relation between face position and fixation duration.

A confounding factor of the methodology of this current study might be the usage of differing facial expressions. The results found in this current study may be explained by the fact that participants looked more at sad and disgusted faces, and that emotional expression and attractiveness are not independent. Disgust and sadness are two facial expressions that are associated negatively with attractiveness (Barzut & Blanuša., 2023; Ueda, Nunoi, & Yoshikawa., 2019), and since the task of the participants was to find the single face that showed one of these two expressions and to correctly identify it, it makes sense that participants looked at unattractive faces for longer periods of time. A possible way to test this hypothesis is to redo the current experiment but instead of using sad and disgusted faces, to use happy faces as the target stimulus. In this modified study, we would expect to find a positive linear correlation between fixation duration and Z-transformed facial attractiveness, as happy faces are positively associated with attractiveness (Lin et al., 2022). If this result is found, it would be imperative to change the methodology to either control for facial expressions, or to find a different method which may work.

A previous study that examined the effects of involuntary attention and task instruction was Folk et al. (1992). Prior to this study, the commonly accepted hypothesis was that cues, no matter if related to the task or not, always would cause involuntary attentional capture. The authors of this study created a new hypothesis called the contingent involuntary orienting hypothesis, which postulates that involuntary attentional shifts will only occur if the cues share a property in common with the task at hand (Folk et al., 1992). This contingent involuntary orienting hypothesis postulates the following two consequences: “If target detection does not require monitoring for an isolated, dynamic discontinuity (e.g., an abrupt onset), there should be no evidence of involuntary shifts to a cue (distractor) containing a similar, isolated, dynamic discontinuity,” (Folk et al., 1992, pg. 1032), and, “If processing of a target requires monitoring for a stimulus property other than an isolated, dynamic discontinuity, such as a static discontinuity in color, then a cue (distractor) containing that property will elicit an involuntary shift of attention,” (Folk et al., 1992, pg. 1032).

The four experiments conducted by Folk et al. (1992) provide evidence in favor of the idea that involuntary attentional shifts occur only when the cues are relevant to the task, and not vice versa. We believe that the contingent involuntary orienting hypothesis proposed by Folk et al. (1992) provides an explanation for the contradictory results found in the current study. Essentially, in the current study, the task of the participants was to find the face which exhibited an emotion, and then to identify the emotion as either sadness or disgust. Since the distractors in the current study were attractive faces with neutral facial expressions, they were not related to the targets which were faces with sad or disgusted expressions, and thus according to the contingent involuntary orienting hypothesis they would not serve as effective distractors. An additional element which complicated our results was the association between attractiveness and facial expressions discussed previously.

Aside from the methodology of the current study, it is also of interest to analyze the methodology used in previous studies that were mentioned in the introduction, to see if perhaps the results that attractiveness and attentional capture are positively correlated can rather be explained by a faulty methodology.

The first study that is important to analyze is Leder et al. (2016) primarily because they measured the same variable as in the present study, gaze duration. To recapitulate Leder et al. (2016) found the opposite of the present study, a positive correlation between gaze duration and attractive facial stimuli. Leder et al. (2016) successfully avoid the pitfalls of the contingent involuntary orienting hypothesis by not providing participants with an explicit task to do during the experiment. In the procedure participants were presented with pictures and were told to just observe them. In the end, participants went through each scene and rated the attractiveness of each face, and then in the last block participants rated the familiarity of each face. Since this experimental procedure did not involve any explicit task, nor any distractors or target stimuli, it can be fairly certain that the results from this study are not influenced by the contingent involuntary orienting hypothesis.

In the first experiment of Valuch et al. (2015), participants looked at a fixation point. Afterwards this point disappeared and was replaced by a face in the center with four placeholders surrounding it. Afterwards, the face disappeared, and a target point appeared in one of the four placeholders. In the overlap condition, the face in the center remained on the screen during the apparition of the target. Participants were informed to “fixate on the face until a dot appears; as soon as you see a dot, look at it as quickly as possible” (Valuch et al., 2015, pg. 3). There also do not seem to be any issues with this procedure, as even in the overlap condition when the face remains on the screen, participants should in theory follow instructions and stop fixating on the face and make a saccade towards the target. Valuch et al. (2015) did not measure gaze duration, instead they measured saccadic speed, so the fact that the face is present for longer in the overlap condition is not a problem.

One last study that can be used as a good example is Faust et al. (2019). To briefly recapitulate the method, participants were presented with a basis number in the bottom center of a screen, and two target numbers on the top left and top right of the screen. Next to each of the target numbers a face was present. The participant’s task was to select the target number which was closest to the basis number. In the congruent condition, an attractive face was next to the correct target number, in the incongruent condition an attractive face was next to the incorrect target number, and finally in the control condition a moderately attractive face was presented next to both the target numbers. This task also seems to work well without possible errors from the contingent involuntary orienting hypothesis. The task is strictly numerical, with the faces serving as distractors. A possible factor which may influence this is the difference between the basis and target numbers, but the authors state that the difference is never greater than five units, which according to them allows for them to control for trial difficulty.

The mouse tracking results all seem to make sense, where maximum deviation, distance, and response time is greater in incongruent trials (attractive face next to incorrect target). The one result which is concerning in the eye tracking results is the fact that for faces placed next to the correct target number, there was no difference in the number of fixations and the fixation duration between attractive faces and unattractive faces. In other words, there was no difference between congruent trials (correct target + attractive face) and a trial with an unattractive face and the correct target. The confusion is that this combination is not defined by the authors. One would think this would be an incongruent condition, but according to the authors the incongruent condition is the combination of an attractive face and the incorrect target. Aside from this, another problem which arrives in this methodology is that the authors do not cite what is the range of the numbers used. If the range between the numbers used in each trial is very large (ex. Double digits in one trial, and four digits in a different trial) then this may increase the cognitive load on executive functions such as working memory. In terms of the contingent involuntary orienting hypothesis, there do not seem to be any issues with this study. Participants are presented with a numerical cue, and the target is also numerical in nature. Thus, the faces presented alongside the two targets are non-task-related, and thus in theory should not cause involuntary attentional shift.

As largely discussed in Maner et al. (2007), the global implications of this study reside in the domain of evolutionary biology. Understanding the underlying attentional biases and mechanisms towards attractive and unattractive faces can help people better understand how sexual selection and behavior related to reproductive strategies is influenced by these factors. If this experiment would be redone in the future by avoiding the pitfalls mentioned above, it would also be interesting to see how people's abilities to recognize, (or a better term, identify) faces plays a role (or does not) in the processing of attractiveness, and how these processes can influence socio-sexual behavior. Perhaps by better understanding the normal functioning of these mechanisms, they can be used to help people who exhibit difficulties in the socio-relational domain.

6. Limitations

There were several limitations that were present in this study. The first is the presence of a categorization bias, specifically when participants had to choose between either a facial expression of disgust or sadness. When there is a forced binary choice, sensibility is lost, so it might be better to instead introduce a sliding scale to measure the degree of sadness or disgust. Another limitation is that our participant population was limited to first year undergraduate university psychology students. While we had equal amounts of men and women, this population is still very specific and so it is not possible to generalize the results found in this study to the general population. This study did not consider sexual preference; the importance of this element is uncertain, as in existing literature this criterion is not explained. The other-race bias (intra-racial facial recognition is easier than inter-racial facial recognition) was not taken into account. The facial recognition test that we used in the study (BFRT-r) was developed in the United Kingdom with solely Caucasian participants. While the majority of participants in the present study were also Caucasian, it might be important to ask the question if this facial recognition test can be applied effectively to other groups of people. Finally, the stimuli from the FACES database used in the visual search paradigm was of German individuals. If this study was to be redone, it might be of interest to create a new database of faces of people locally in Geneva, or in Switzerland in general.

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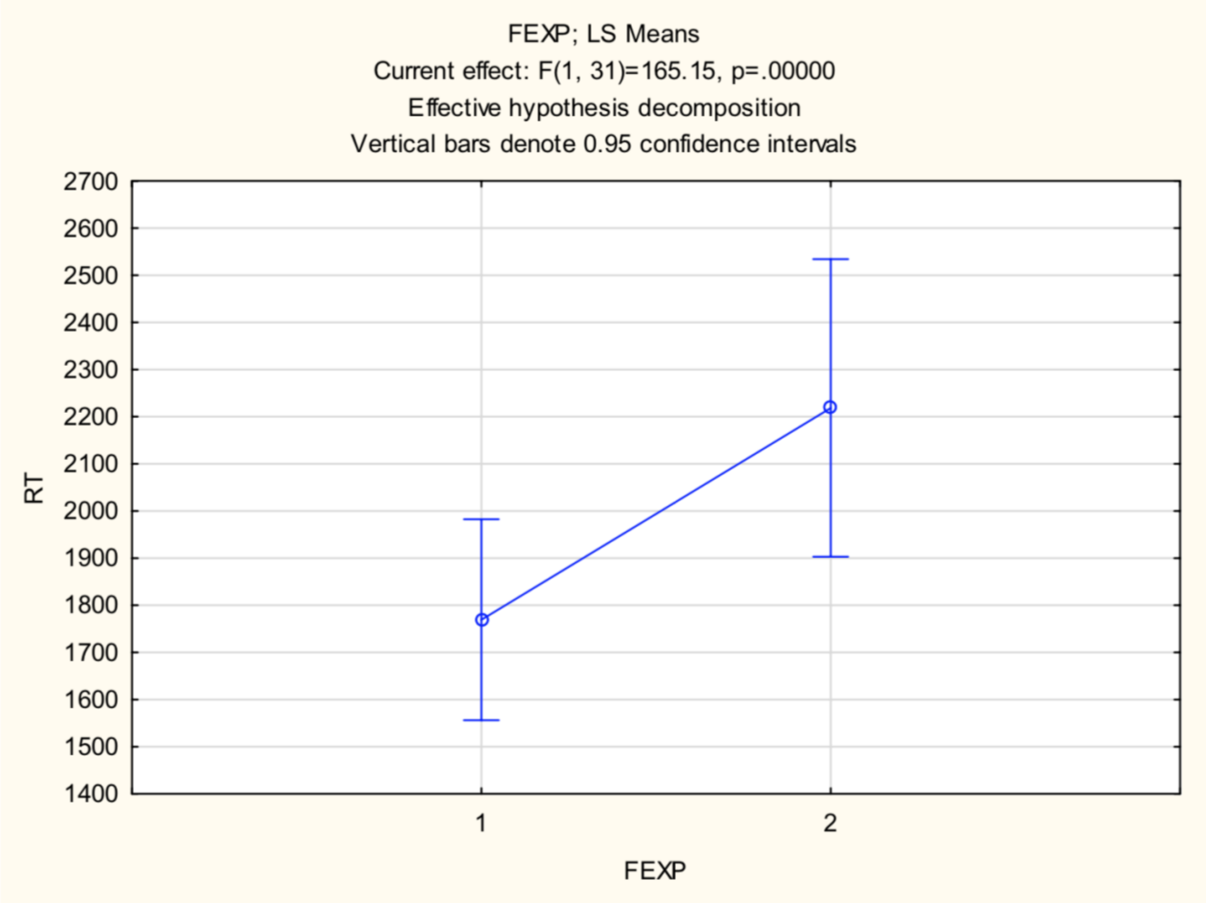
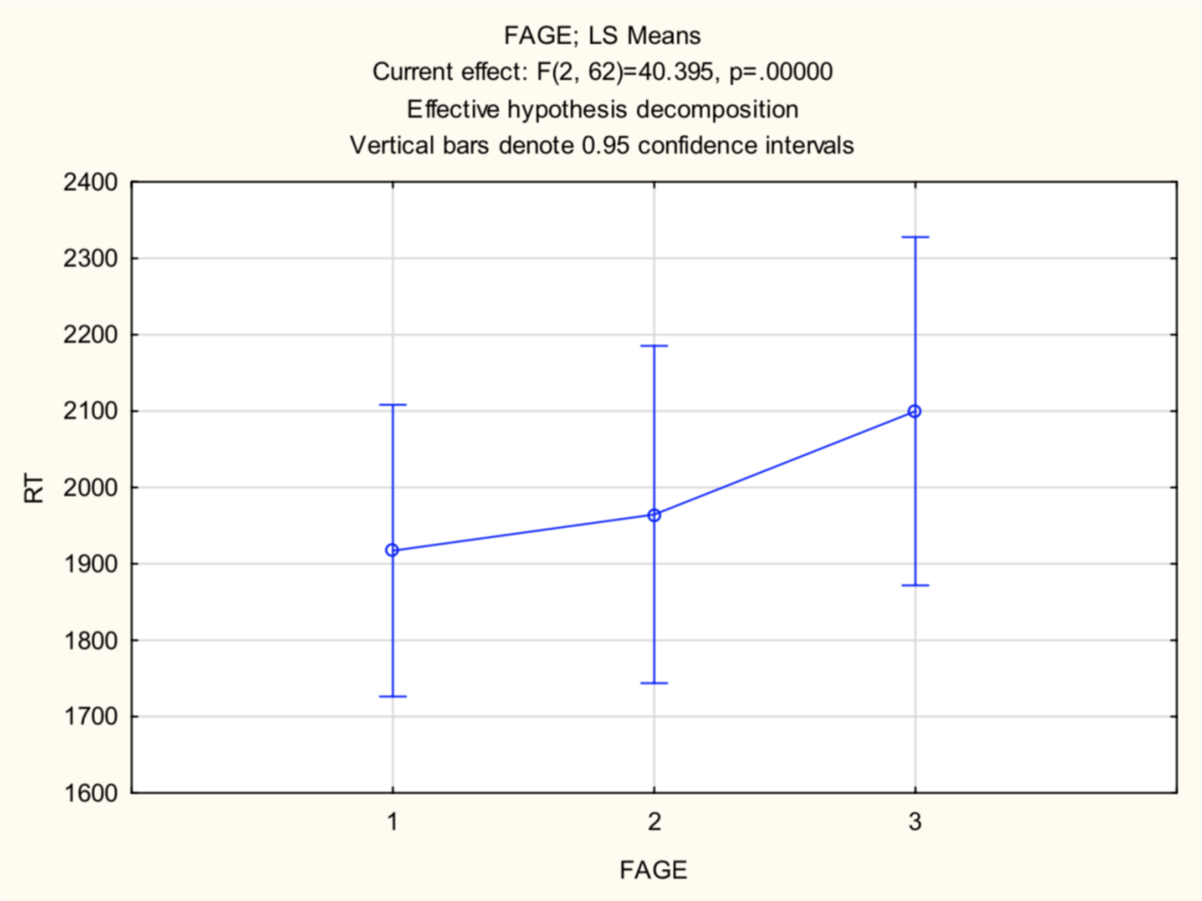
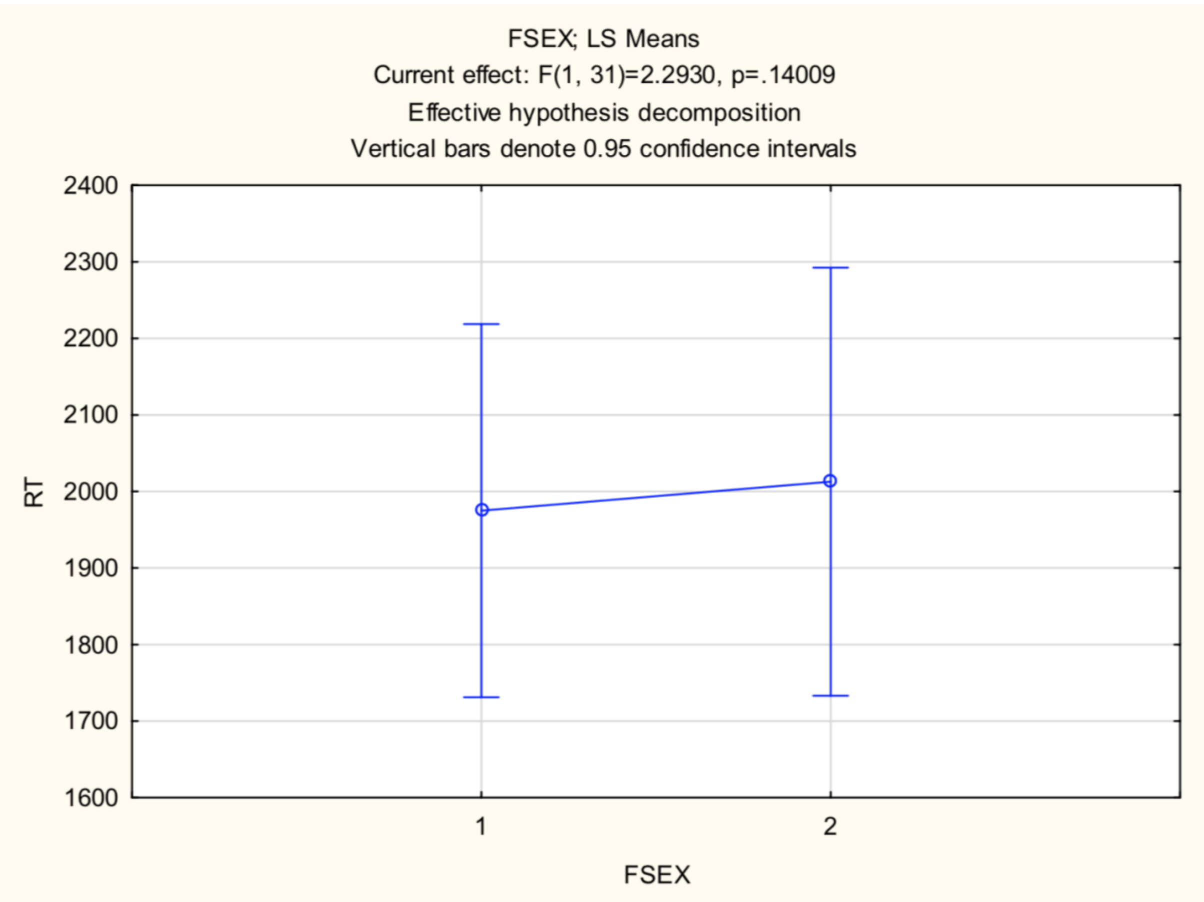
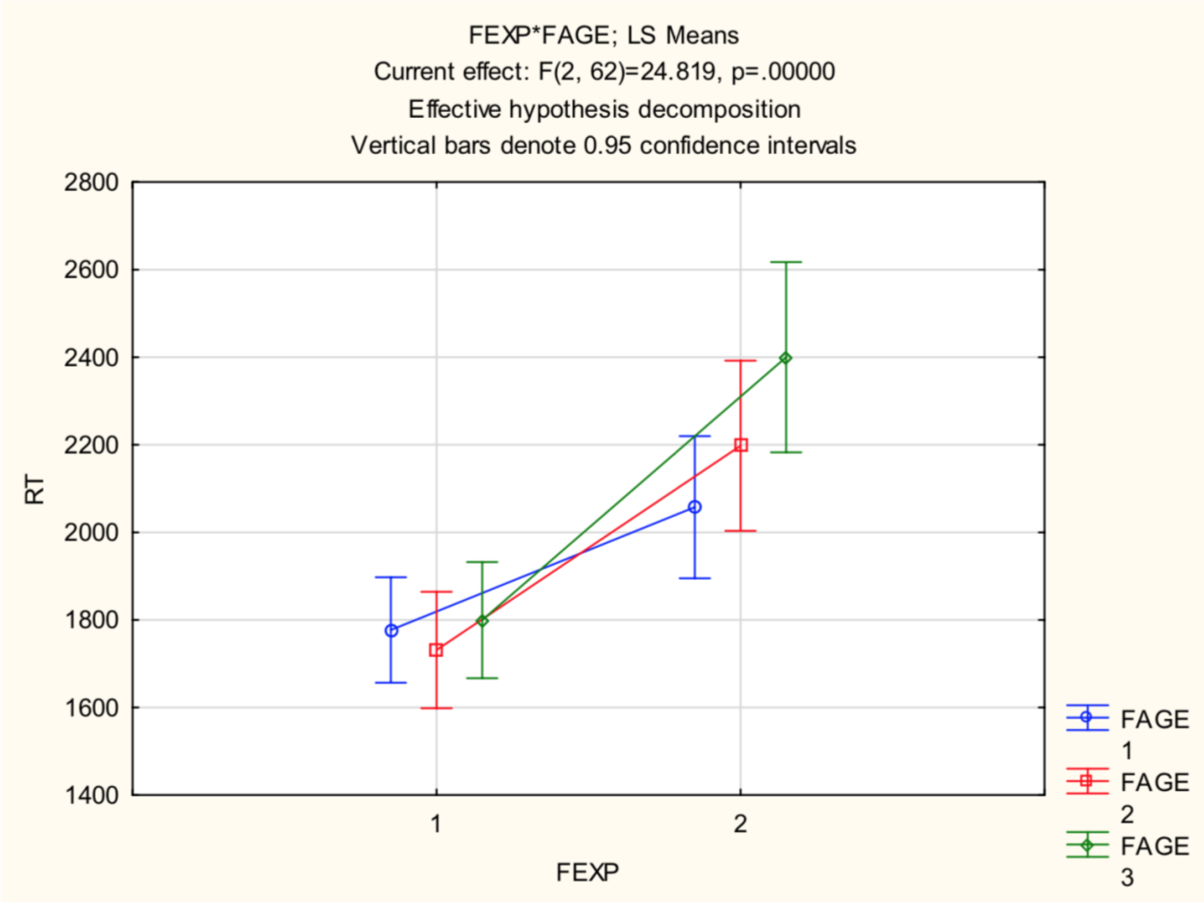
8. Annex

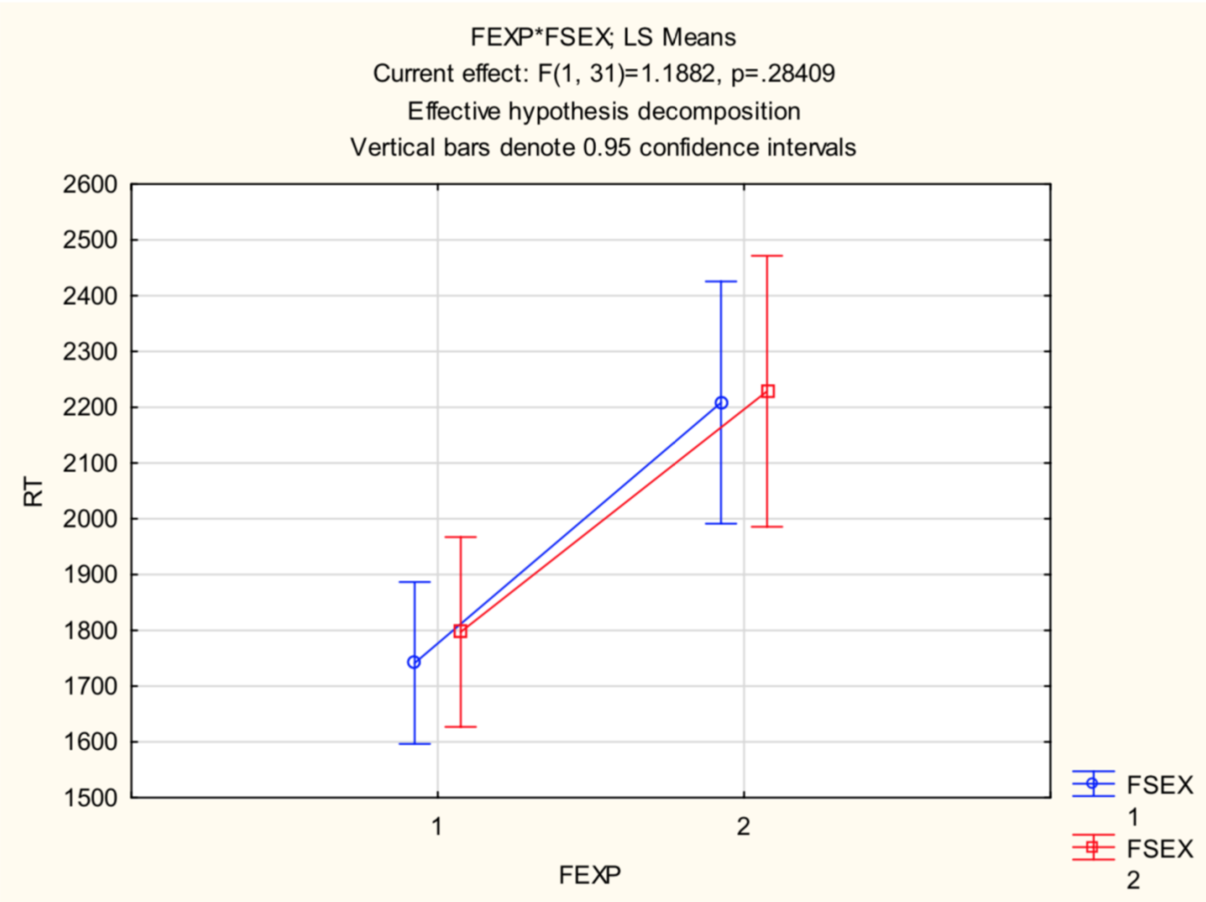
8.1 Annex I: Results of ANOVA on Reaction Time

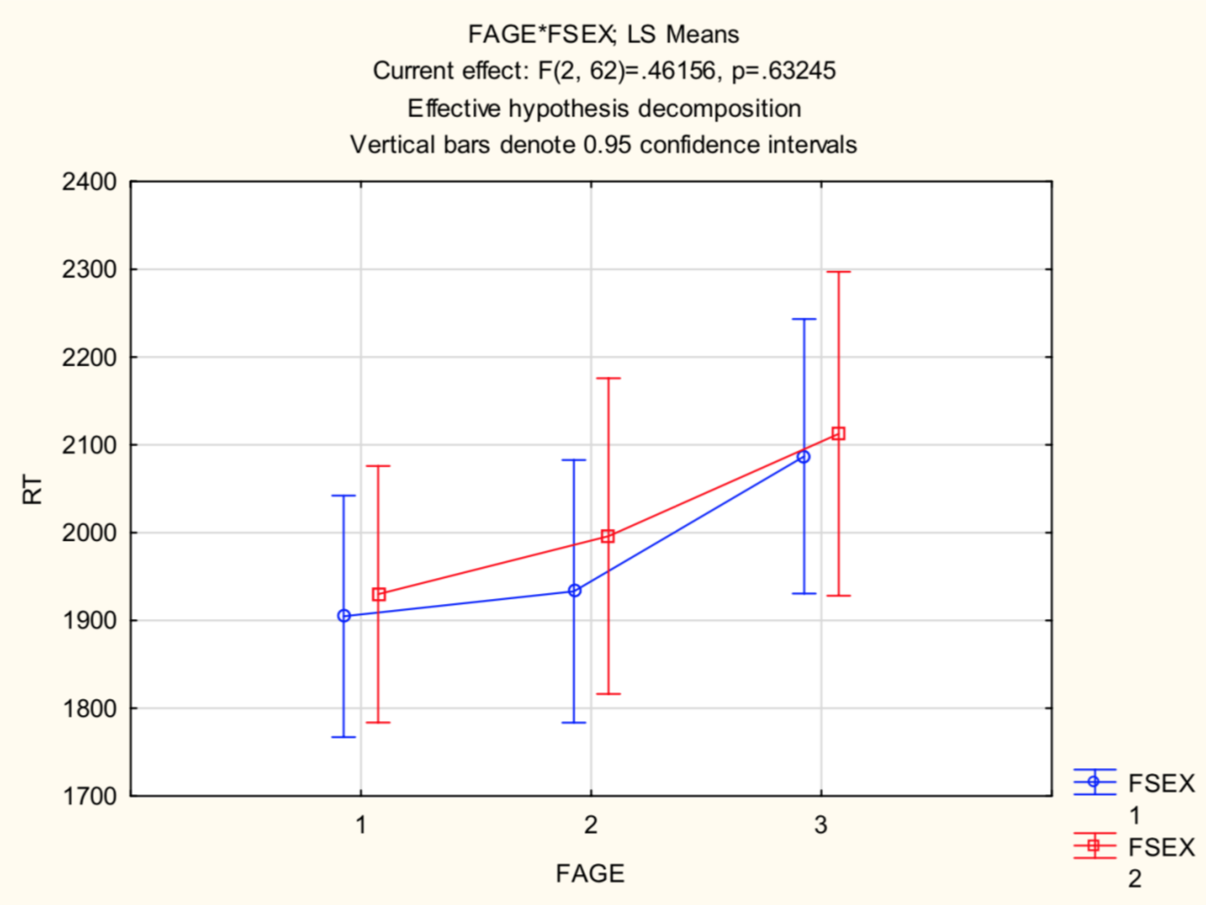


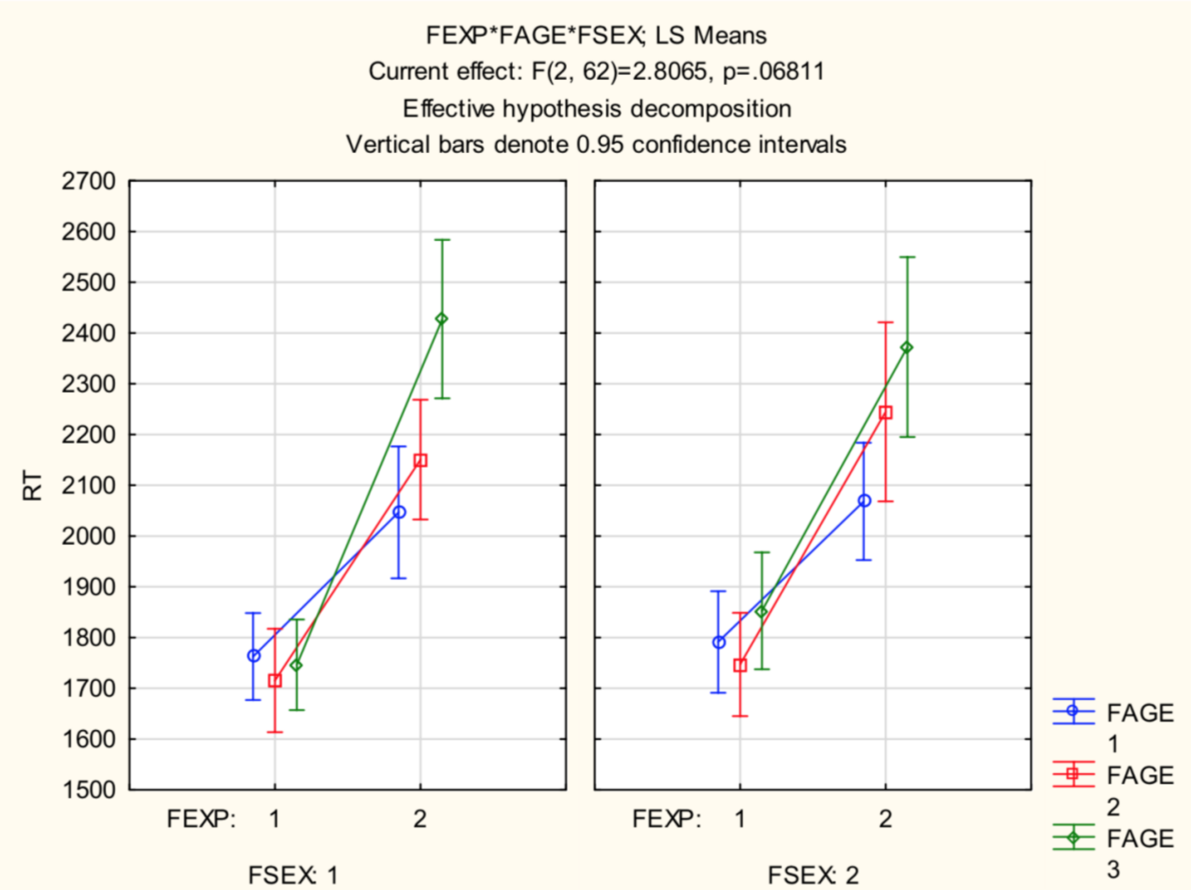

FAGE; LS Means
Current effect: F(2, 62)=40.395, p=.00000
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
2400
2300
2200
2100
2000
1900
1800
1700
1600
RT
1
2
3
FAGE


FSEX; LS Means
Current effect: F(1, 31)=2.2930, p=.14009
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
2400
2300
2200
2100
2000
1900
1800
1700
1600
RT
1
2
FSEX


FEXP*FAGE; LS Means
Current effect: F(2, 62)=24.819, p=.00000
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
RT
FEXP
FAGE 1
FAGE 2
FAGE 3


FEXP*FSEX; LS Means
Current effect: F(1, 31)=1.1882, p=.28409
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
RT
FEXP
FSEX 1
FSEX 2


FAGE*FSEX; LS Means
Current effect: F(2, 62)=.46156, p=.63245
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
RT
2400
2300
2200
2100
2000
1900
1800
1700
1
2
3
FAGE
FSEX 1
FSEX 2


FEXP*FAGE*FSEX; LS Means
Current effect: F(2, 62)=2.8065, p=.06811
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
RT
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
FEXP: 1 2
FSEX: 1
FEXP: 1 2
FSEX: 2
FAGE 1
FAGE 2
FAGE 3

Effect	Repeated Measures Analysis of Variance with Effect Sizes and Powers Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	*1.526586E+09*	*1*	*1.526586E+09*	*1528.710*	*0.000000*
Error	3.095695E+07	31	9.986111E+05		
FEXP	*1.936672E+07*	*1*	*1.936672E+07*	*165.153*	*0.000000*
Error	3.635229E+06	31	1.172654E+05		
FAGE	*2.297418E+06*	*2*	*1.148709E+06*	*40.395*	*0.000000*
Error	1.763089E+06	62	2.843692E+04		
FSEX	1.379788E+05	1	1.379788E+05	2.293	0.140090
Error	1.865400E+06	31	6.017420E+04		
FEXP*FAGE	*1.652553E+06*	*2*	*8.262767E+05*	*24.819*	*0.000000*
Error	2.064104E+06	62	3.329201E+04		
FEXP*FSEX	3.015732E+04	1	3.015732E+04	1.188	0.284090
Error	7.867866E+05	31	2.538021E+04		
FAGE*FSEX	2.995308E+04	2	1.497654E+04	0.462	0.632450
Error	2.011774E+06	62	3.244796E+04		
FEXP*FAGE*FSEX	2.095529E+05	2	1.047764E+05	2.807	0.068109
Error	2.314673E+06	62	3.733343E+04		

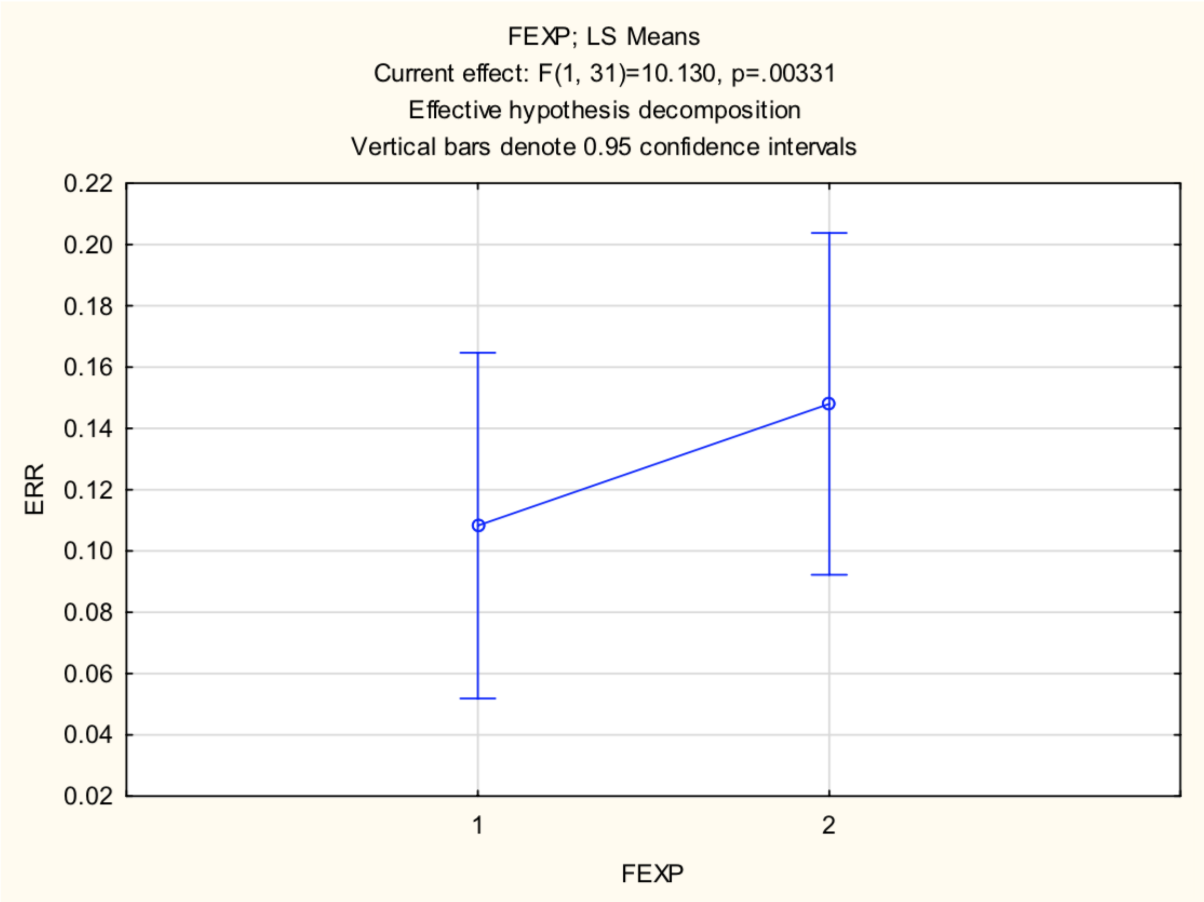
Effect	Repeated Measures Analysis of Variance with Effect Sizes and Powers Sigma-restricted parameterization Effective hypothesis decomposition Partial eta-squared	Non-centrality	Observed power (alpha=0.05)
Intercept	*0.980125*	*1528.710*	*1.000000*
Error			
FEXP	*0.841960*	*165.153*	*1.000000*
Error			
FAGE	*0.565796*	*80.790*	*1.000000*
Error			
FSEX	0.068873	2.293	0.311490
Error			
FEXP*FAGE	*0.444634*	*49.638*	*0.999997*
Error			
FEXP*FSEX	0.036915	1.188	0.184421
Error			
FAGE*FSEX	0.014670	0.923	0.122075
Error			
FEXP*FAGE*FSEX	0.083017	5.613	0.532555
Error			

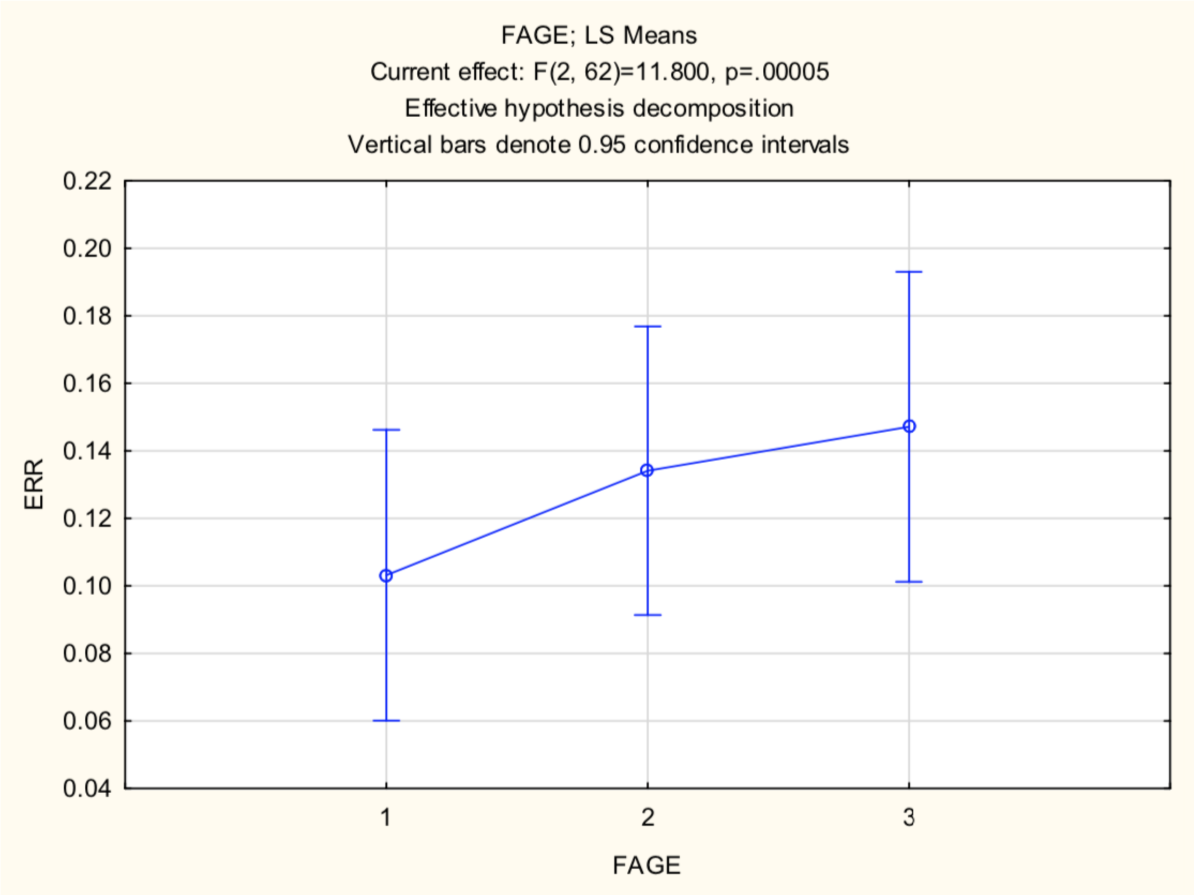
Effect	Adjusted Univariate Tests for Repeated Measure: RT Sigma-restricted parameterization Effective hypothesis decomposition Degr. of Freedom	F	p	G-G Epsilon	G-G Adj. df1	G-G Adj. df2
FEXP	*1*	*165.1528*	*0.000000*	*1.000000*	*1.000000*	*31.00000*
Error	31					
FAGE	*2*	*40.3950*	*0.000000*	*0.945880*	*1.891761*	*58.64459*
Error	62					
FSEX	1	2.2930	0.140090	1.000000	1.000000	31.00000
Error	31					
FEXP*FAGE	*2*	*24.8191*	*0.000000*	*0.854354*	*1.708708*	*52.96995*
Error	62					
FEXP*FSEX	1	1.1882	0.284090	1.000000	1.000000	31.00000
Error	31					
FAGE*FSEX	2	0.4616	0.632450	0.930746	1.861492	57.70624
Error	62					
FEXP*FAGE*FSEX	2	2.8065	0.068109	0.894169	1.788339	55.43850
Error	62					

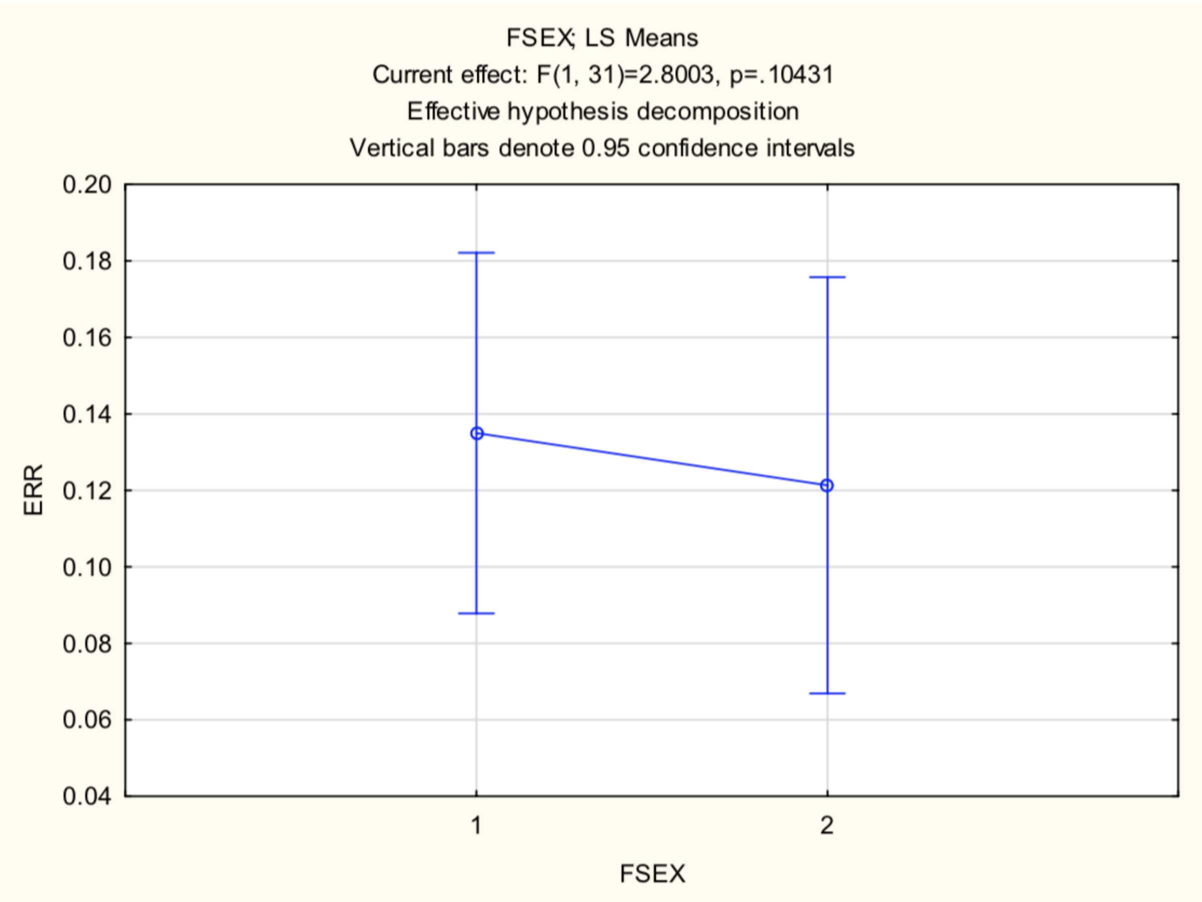
Effect	Adjusted Univariate Tests for Repeated Measure: RT Sigma-restricted parameterization Effective hypothesis decomposition G-G Adj. p	H-F Epsilon	H-F Adj. df1	H-F Adj. df2	H-F Adj. p	Lowr.Bnd Epsilon
FEXP	*0.000000*	*1.000000*	*1.000000*	*31.00000*	*0.000000*	*1.000000*
Error						
FAGE	*0.000000*	*1.000000*	*2.000000*	*62.00000*	*0.000000*	*0.500000*
Error						
FSEX	0.140090	1.000000	1.000000	31.00000	0.140090	1.000000
Error						
FEXP*FAGE	*0.000000*	*0.899220*	*1.798441*	*55.75167*	*0.000000*	*0.500000*
Error						
FEXP*FSEX	0.284090	1.000000	1.000000	31.00000	0.284090	1.000000
Error						
FAGE*FSEX	0.618757	0.987829	1.975658	61.24540	0.630113	0.500000
Error						
FEXP*FAGE*FSEX	0.074720	0.945288	1.890575	58.60783	0.071455	0.500000
Error						

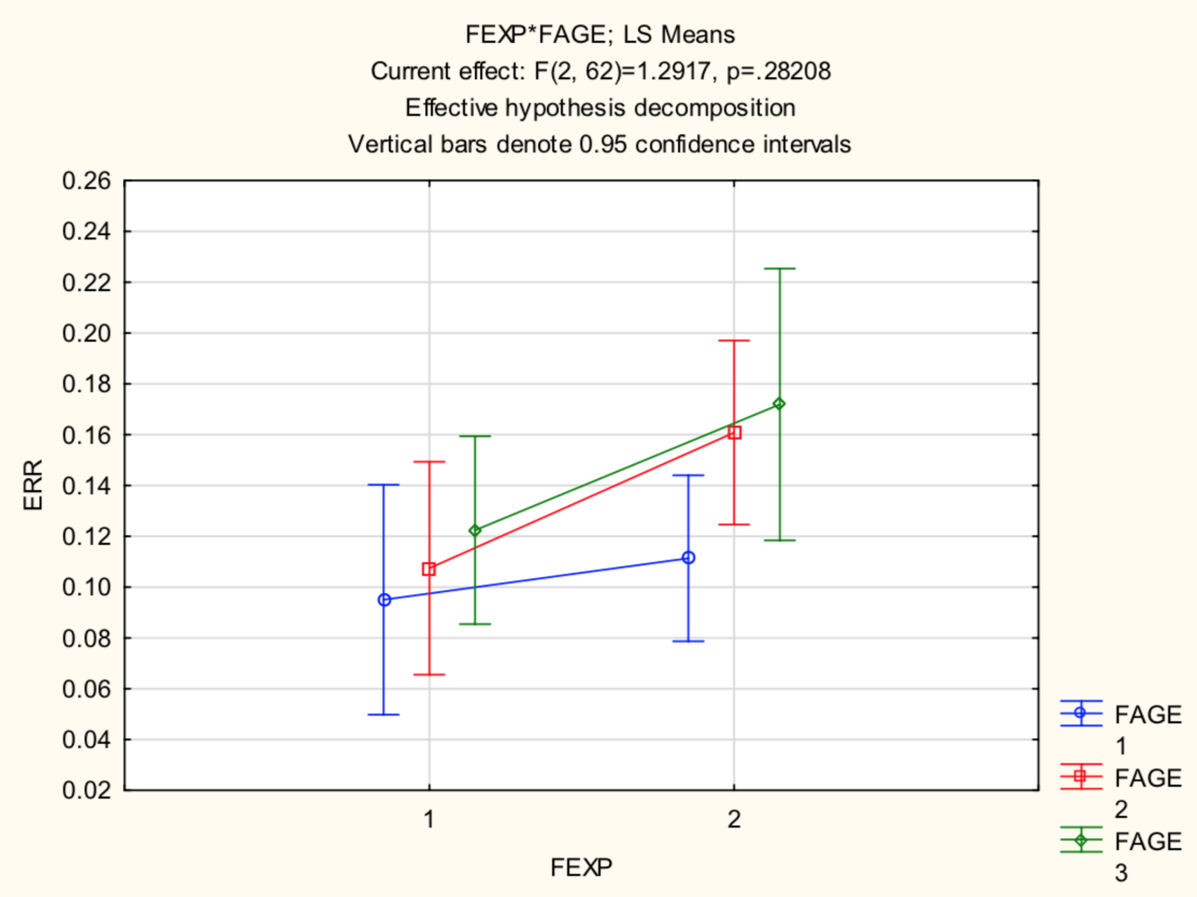
Effect	Adjusted Univariate Tests for Repeated Measure: RT Sigma-restricted parameterization		
	Lowr.Bnd Adj. df1	Lowr.Bnd Adj. df2	Lowr.Bnd Adj. p
FEXP	*1.000000*	*31.00000*	*0.000000*
Error			
FAGE	*1.000000*	*31.00000*	*0.000000*
Error			
FSEX	1.000000	31.00000	0.140090
Error			
FEXP*FAGE	*1.000000*	*31.00000*	*0.000023*
Error			
FEXP*FSEX	1.000000	31.00000	0.284090
Error			
FAGE*FSEX	1.000000	31.00000	0.501939
Error			
FEXP*FAGE*FSEX	1.000000	31.00000	0.103943
Error			

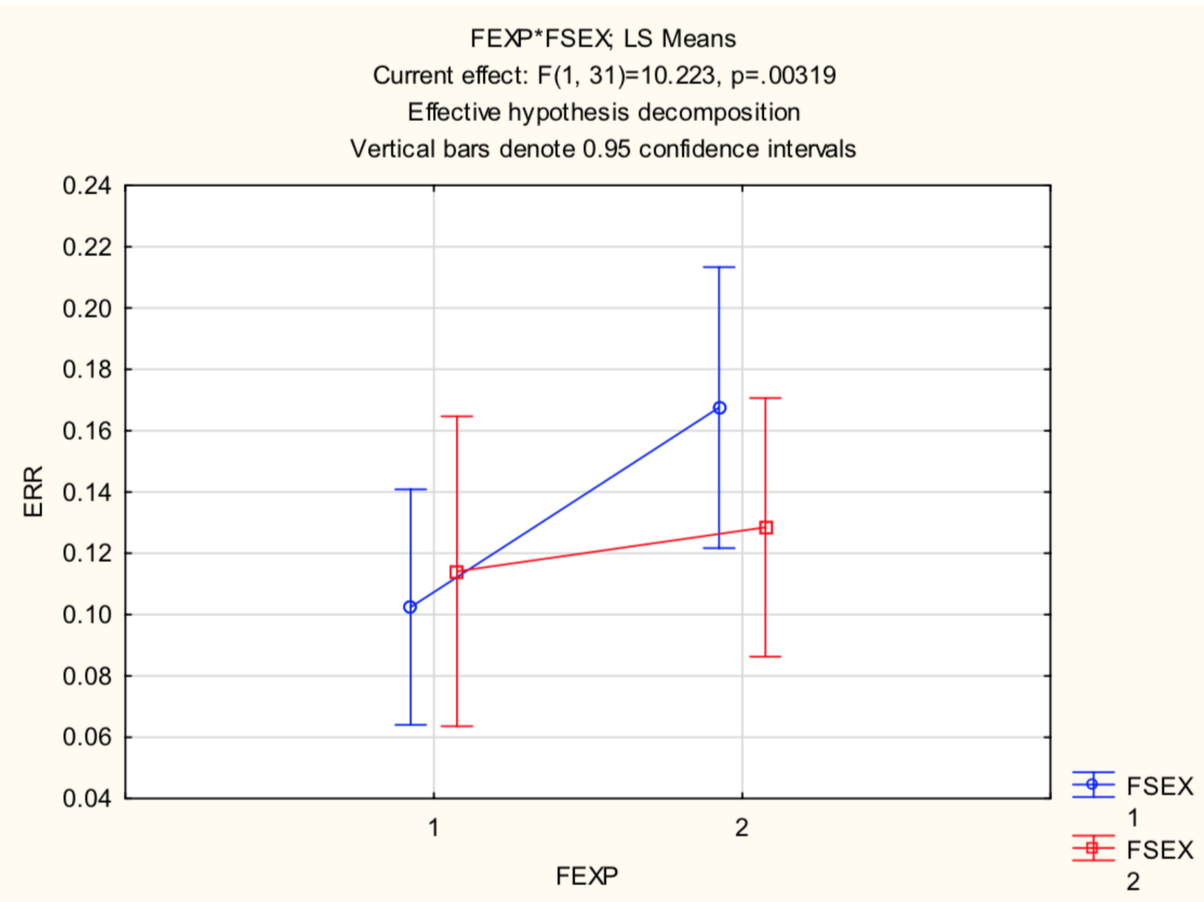
8.2 Annex II: Results of ANOVA on Proportion of Decision Errors

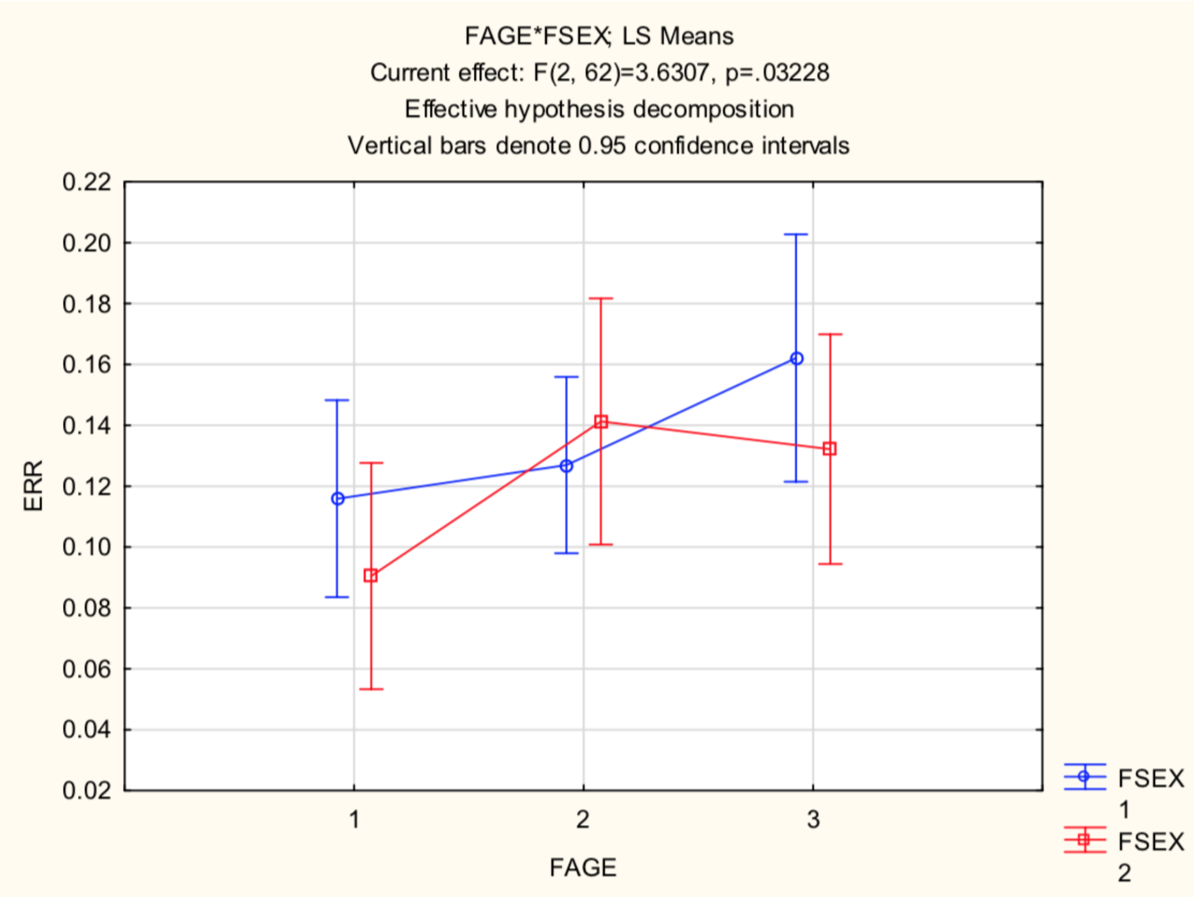


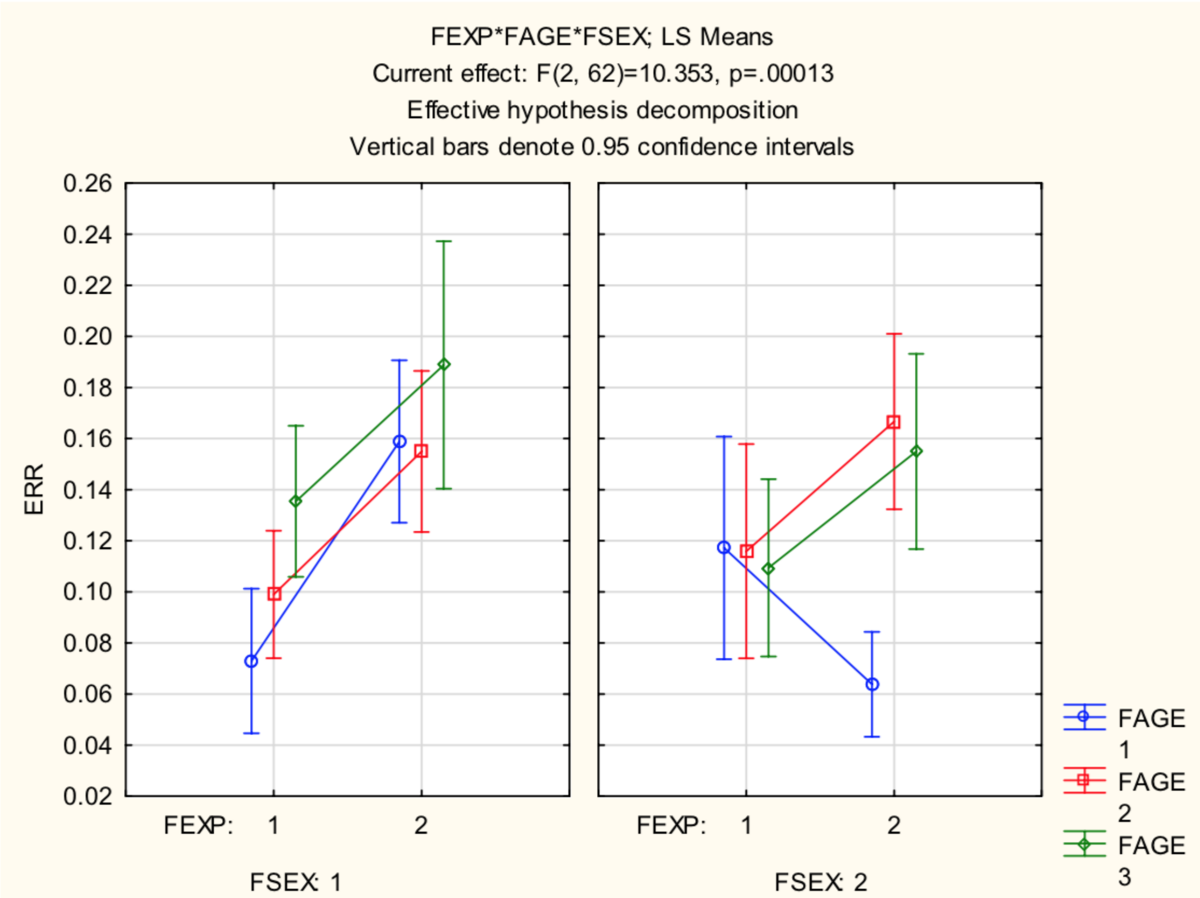

FAGE; LS Means
Current effect: F(2, 62)=11.800, p=.00005
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
1
2
3
FAGE


FSEX; LS Means
Current effect: F(1, 31)=2.8003, p=.10431
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
1
2
FSEX


FEXP*FAGE; LS Means
Current effect: F(2, 62)=1.2917, p=.28208
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
1
2
FEXP
FAGE 1
FAGE 2
FAGE 3


FEXP*FSEX; LS Means
Current effect: F(1, 31)=10.223, p=.00319
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
1
2
FEXP
FSEX 1
FSEX 2


FAGE*FSEX; LS Means
Current effect: F(2, 62)=3.6307, p=.03228
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
1
2
3
FAGE
FSEX 1
FSEX 2


FEXP*FAGE*FSEX; LS Means
Current effect: F(2, 62)=10.353, p=.00013
Effective hypothesis decomposition
Vertical bars denote 0.95 confidence intervals
ERR
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
FEXP: 1 2
FSEX: 1
FEXP: 1 2
FSEX: 2
FAGE 1
FAGE 2
FAGE 3

Effect	Repeated Measures Analysis of Variance with Effect Sizes and Powers Sigma-restricted parameterization				
	SS	Degr. of Freedom	MS	F	p
Intercept	6.305918	1	6.305918	188.4321	0.000000
Error	1.037421	31	0.033465		
FEXP	0.151409	1	0.151409	10.1305	0.003309
Error	0.463321	31	0.014946		
FAGE	0.130434	2	0.065217	11.8004	0.000045
Error	0.342652	62	0.005527		
FSEX	0.017943	1	0.017943	2.8003	0.104309
Error	0.198635	31	0.006408		
FEXP*FAGE	0.026610	2	0.013305	1.2917	0.282082
Error	0.638611	62	0.010300		
FEXP*FSEX	0.061891	1	0.061891	10.2229	0.003187
Error	0.187678	31	0.006054		
FAGE*FSEX	0.037950	2	0.018975	3.6307	0.032279
Error	0.324028	62	0.005226		
FEXP*FAGE*FSEX	0.094100	2	0.047050	10.3528	0.000132
Error	0.281767	62	0.004545		

Effect	Repeated Measures Analysis of Variance with Effect Sizes and Powers Sigma-restricted parameterization Effective hypothesis decomposition		
	Partial eta-squared	Non-centrality	Observed power (alpha=0.05)
Intercept	0.858726	188.4321	1.000000
Error			
FEXP	0.246301	10.1305	0.869252
Error			
FAGE	0.275708	23.6009	0.992629
Error			
FSEX	0.082849	2.8003	0.367724
Error			
FEXP*FAGE	0.040002	2.5835	0.269833
Error			
FEXP*FSEX	0.247990	10.2229	0.872204
Error			
FAGE*FSEX	0.104840	7.2613	0.649867
Error			
FEXP*FAGE*FSEX	0.250354	20.7057	0.983990
Error			

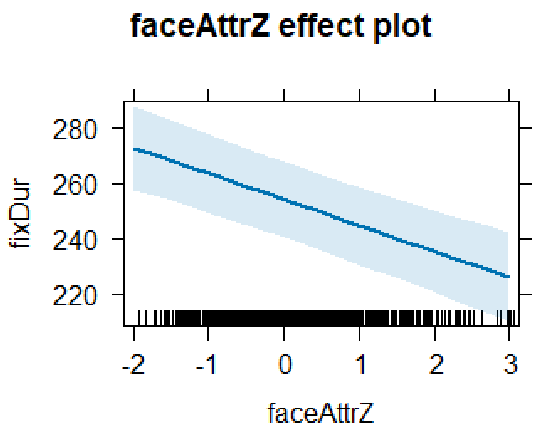
Effect	Adjusted Univariate Tests for Repeated Measure: ERR Sigma-restricted parameterization Effective hypothesis decomposition Degr. of Freedom	F	p	G-G Epsilon	G-G Adj. df1	G-G Adj. df2
FEXP	*1*	*10.13048*	*0.003309*	*1.000000*	*1.000000*	*31.00000*
Error	31					
FAGE	*2*	*11.80044*	*0.000045*	*0.896304*	*1.792608*	*55.57084*
Error	62					
FSEX	1	2.80031	0.104309	1.000000	1.000000	31.00000
Error	31					
FEXP*FAGE	2	1.29174	0.282082	0.859816	1.719632	53.30859
Error	62					
FEXP*FSEX	*1*	*10.22287*	*0.003187*	*1.000000*	*1.000000*	*31.00000*
Error	31					
FAGE*FSEX	*2*	*3.63067*	*0.032279*	*0.981596*	*1.963193*	*60.85898*
Error	62					
FEXP*FAGE*FSEX	*2*	*10.35284*	*0.000132*	*0.997853*	*1.995705*	*61.86686*
Error	62					

Effect	Adjusted Univariate Tests for Repeated Measure: ERR Sigma-restricted parameterization Effective hypothesis decomposition G-G Adj. p	H-F Epsilon	H-F Adj. df1	H-F Adj. df2	H-F Adj. p	Lowr.Bnd Epsilon
FEXP	*0.003309*	*1.000000*	*1.000000*	*31.00000*	*0.003309*	*1.000000*
Error						
FAGE	*0.000096*	*0.947764*	*1.895529*	*58.76139*	*0.000066*	*0.500000*
Error						
FSEX	0.104309	1.000000	1.000000	31.00000	0.104309	1.000000
Error						
FEXP*FAGE	0.280110	0.905525	1.811051	56.14257	0.280909	0.500000
Error						
FEXP*FSEX	*0.003187*	*1.000000*	*1.000000*	*31.00000*	*0.003187*	*1.000000*
Error						
FAGE*FSEX	*0.033148*	*1.000000*	*2.000000*	*62.00000*	*0.032279*	0.500000
Error						
FEXP*FAGE*FSEX	*0.000134*	*1.000000*	*2.000000*	*62.00000*	*0.000132*	*0.500000*
Error						

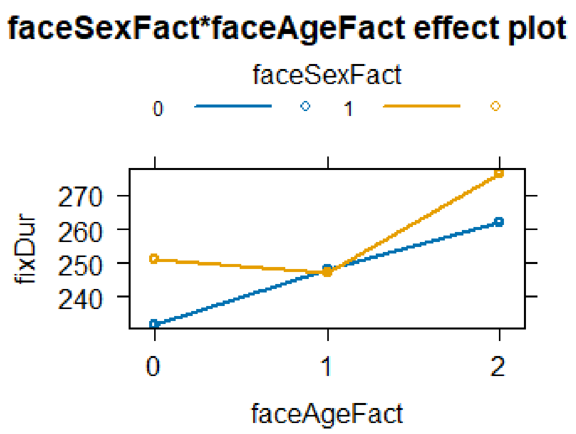
Effect	Adjusted Univariate Tests for Repeated Measure: ERR Sigma-restricted parameterization Lowr.Bnd Adj. df1	Lowr.Bnd Adj. df2	Lowr.Bnd Adj. p
FEXP	1.000000	31.00000	0.003309
Error			
FAGE	1.000000	31.00000	0.001704
Error			
FSEX	1.000000	31.00000	0.104309
Error			
FEXP*FAGE	1.000000	31.00000	0.264437
Error			
FEXP*FSEX	1.000000	31.00000	0.003187
Error			
FAGE*FSEX	1.000000	31.00000	0.066035
Error			
FEXP*FAGE*FSEX	1.000000	31.00000	0.003023
Error			

8.3 Annex III: Results of mixed linear model

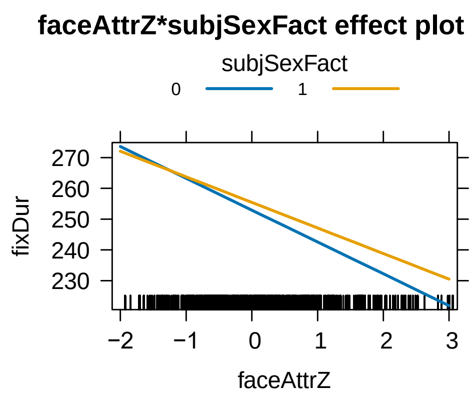
```
m3r0 = lmer(fixDur ~ faceAttrZ + faceAttrZ*subjSexFact + faceSexFact*faceAgeFact + posFact
            + (1|subjFact) + (1|subjFact:faceSexFact)+ (1|subjFact:faceAgeFact)+ (faceAttr
Z-1|subjFact),
            data=e1, subset = (targFact=="0"))

Type III Analysis of Variance Table with Satterthwaite's method
                         Sum Sq Mean Sq NumDF   DenDF F value                Pr(>F)
faceAttrZ                778431  778431     1    40.9 38.8277 0.00000020561309945 ***
subjSexFact                 618     618     1    30.1  0.0308             0.861795
faceSexFact              221937  221937     1    32.0 11.0701             0.002215 **
faceAgeFact             1337806  668903     2    64.4 33.3645 0.0000000011354257 ***
posFact                 1441860  288372     5 30431.7 14.3838 0.00000000000004246 ***
faceAttrZ:subjSexFact     10655   10655     1    31.5  0.5315             0.471371
faceSexFact:faceAgeFact  531550  265775     2 30410.4 13.2567 0.00000175869495118 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

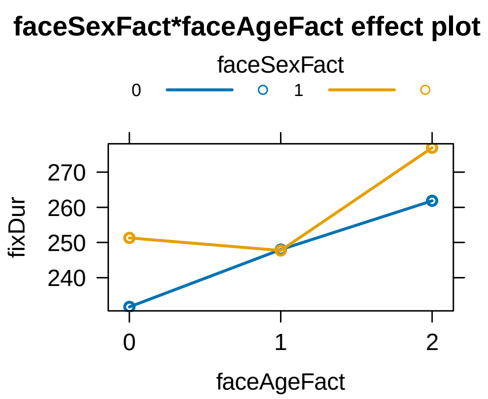

faceAttrZ effect plot
fixDur
280
260
240
220
-2
-1
0
1
2
3
faceAttrZ


posFact effect plot
fixDur
270
260
250
240
230
1
2
3
4
5
6
posFact


faceSexFact*faceAgeFact effect plot
faceSexFact
0
1
fixDur
270
260
250
240
0
1
2
faceAgeFact


posFact effect plot
fixDur
270
260
250
240
230
1
2
3
4
5
6
posFact


faceAttrZ*subjSexFact effect plot
subjSexFact
0
1
fixDur
270
260
250
240
230
−2
−1
0
1
2
3
faceAttrZ


faceSexFact*faceAgeFact effect plot
faceSexFact
0
1
fixDur
270
260
250
240
0
1
2
faceAgeFact

8.4 Annex IV: Results of Spearman Correlations

Variable	Spearman Rank Order Correlations MD pairwise deleted Marked correlations are significant at p <.05000	
	BENTON	SLOPE
BENTON	1.000000	-0.154725
SLOPE	-0.154725	1.000000

Variable	Spearman Rank Order Correlations MD pairwise deleted Marked correlations are significant at p <.05000	
	BENTON	Mean_RT
BENTON	1.000000	0.171099
Mean_RT	0.171099	1.000000

Variable	Spearman Rank Order Correlations MD pairwise deleted Marked correlations are significant at p <.05000	
	Mean_RT	Mean_ERR
Mean_RT	1.000000	-0.249129
Mean_ERR	-0.249129	1.000000