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FACULTEIT PSYCHOLOGIE EN
PEDAGOGISCHE WETENSCHAPPEN

Laboratorium voor
Experimentele Psychologie

ARE VIEWING PATTERNS IN INDIVIDUALS WITH ASD CONFINED TO THE EYE REGION?

A meta-analysis on social attention and feature saliency.

Master's thesis submitted to obtain the
degree of Master of Science in de
pedagogische wetenschappen by
Evi Coosemans and in psychologie by
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SUMMARY

Autism Spectrum Disorders (ASD) are a group of neurodevelopmental disorders characterized by impairments in social interaction and communication in combination with restricted and repetitive behavior patterns and interests. In addition, ASD is also characterized by atypical visual processing, incl. face perception. A vast amount of research has focused on finding an explanation for the differences in face processing strategies between individuals with ASD and neurotypical individuals. One research area concerns the atypical saliency of faces and facial features in ASD, a characteristic that is clearly noticeable in everyday situations.

Some studies found evidence for atypical patterns of social attention in individuals with ASD, mainly characterized by decreased saliency of faces and the eye region, and an increased saliency of the background and the mouth area. However, some experiments could not replicate these group differences in viewing patterns. Therefore, the main objective of this meta-analysis was to examine the currently available empirical studies and to combine their inconsistent results through meta-analytic techniques. In this way, we quantified the evidence for atypical saliency of facial features in ASD. In addition, we detected possible moderator variables that could explain the ambiguous results in the literature.

The results of our meta-analysis confirm the hypothesis that individuals with ASD direct significantly less social attention towards the eyes. However, this divergent gaze pattern for the ASD sample is not restricted towards the eye region, but includes the whole inner face area: all core facial features, being the eyes, nose and mouth, are less salient for individuals with ASD. Furthermore, the ASD sample shows a clear attentional bias towards less informative regions, such as the external facial features (cheek, hair, chin etc.) and background regions (bodies, limbs and objects in the scene). These gaze patterns are most pronounced in the predominantly male participant groups and for participants aged between 12 and 25 years old.

Additional analyses revealed the importance of task instructions in moderating the atypical preferential bias in ASD, as the inclusion of certain task demands can reduce the saliency of the background areas and external facial features. However, this does not moderate the saliency of the core facial features, since individuals with ASD remain to direct less social attention to these regions than their typical matches.

ACKNOWLEDGMENTS

This master thesis is the end product of a two year lasting process and of a successful partnership between Evi Coosemans and Jellina Prinsen. Working in team brings forth certain challenges, but we were able to benefit from it because of our complementary research abilities and the large amount of support we got from one another. Besides our personal effort to complete this master thesis successfully, this could not have been accomplished without the help and support of certain persons.

First we wish to express our sincere gratitude to our promotor, Prof. Dr. Johan Wagemans, for his guidance and encouragement throughout this process. Especially his idea to present our findings at one of the lab meetings, as a chance to receive feedback from other researchers with already heaps of experience, was of great value.

Secondly, we want to express thankfulness to Kris Evers for her always constructive advice concerning the contents and structure of this master thesis. Her feedback on our thoughts and manuscript as well as her optimism made this thesis into a positive learning experience. We also want to thank Ruth Van der Hallen for her useful input during discussion sessions and all other members of the Laboratory of Experimental Psychology for their considerations.

And last but not least, a lot of other persons, who were not directly involved in our research, were of great value for the successful completion of this thesis. Therefore we would like to thank our friends and family, who would motivate and encourage us if we encountered difficulties in this laboriously but educational process, for their moral support.

Our sincere thanks goes out to all of you,

Evi Coosemans &
Jellina Prinsen
Leuven, juni 2015

CONTRIBUTION & INVOLVEMENT

Writing a master thesis means a lot of hard work. For this meta-analysis we had to search, select, code and analyse a large number of articles. The entire meta-analytic process has been labour intensive and we would not have been able to complete it without the support and feedback of Prof. Johan Wagemans, Kris Evers and Ruth Van der Hallen.

As a first step, Kris Evers provided us with some introductory literature on the visual processing and face perception in ASD as a general background, to obtain an insight in the used paradigms and in the variety of studies. Together with our supervisors, we constructed a Boolean search term, which we ran in different web databases to test for its sensibility. After the search term was perfected, we obtained a collection of 2621 articles by means of a computerized literature search. Additionally, a manual literature search of the reference and citation lists of 10 key papers was performed by us to check for all relevant papers.

Secondly, we created a set of inclusion and exclusion criteria, together with our supervisors. Together with the help of our supervisors, we processed over 2,600 articles that were yielded by our broad initial search. For pragmatic reasons, we chose to code papers within one research topic, namely the saliency of different facial features. With the help of our supervisors, we then constructed a detailed coding scheme, which embraced all relevant material for this meta-analysis. The two of us coded, analysed and categorized over 50 papers, constructing an all-encompassing and very detailed data sheet.

With the support and a basic code of our supervisors, we performed the analyses in SAS ourselves. Because we had a large amount of coded variables, our supervisors assisted us in selecting the most relevant aspects in the statistical analyses.

Writing this master thesis truly was a team effort since we wrote the entire text ourselves incorporating the feedback of our supervisors. Because of the scientific focus, we chose to write our master thesis in the form of an English scientific article. We hope to be able to present our findings in a scientific journal such as *Journal of Autism and Developmental Disorders* or *Research in Autism Spectrum Disorders*.

TABLE OF CONTENT

INTRODUCTION

1. Autism Spectrum Disorders

Autism Spectrum Disorders (ASD) are a group of early onset neurodevelopmental conditions. The DSM-IV-TR used the term Pervasive Developmental Disorders (PDD) to refer to individuals with the following impairments: (1) severe and pervasive deficits in social interaction and (2) communication; and (3) a restricted and repetitive range of behaviors, interests and activities. Five different subtypes were distinguished within the broad PDD cluster: Autistic Disorder (AD), Asperger's Syndrome (AS), PDD–Not Otherwise Specified (PDD-NOS), Rett's Syndrome and Childhood Disintegrative Disorder (American Psychiatric Association, 2000). Together with the new DSM-5 (American Psychiatric Association, 2013), the term Autism Spectrum Disorder (ASD) was introduced, without further division into subtypes. Moreover, individuals with ASD are now characterized by a duality of symptom clusters instead of the classical triad: impairments in social interaction and social communication have been merged together, in addition to restricted and repetitive behavior patterns and interests.

Recent epidemiological studies suggest a prevalence rate for ASD of around 1% in the United States (Centers for Disease Control and Prevention, 2012). This number is also applicable to other industrialized countries. There is a remarkable gender difference, since prevalence rates are approximately four times higher among males than females (American Psychiatric Association, 2013). Furthermore, it has been noted that 70% of all individuals with ASD have a comorbid mental disorder and that 40% of them has two or more mental disorders (American Psychiatric Association, 2013). For example, ASD is frequently linked with intellectual impairments or Attention-Deficit/Hyperactivity Disorder (AD/HD). The prevalence of comorbid language deficits and somatic disorders such as epilepsy, is also increased in ASD (American Psychiatric Association, 2013). Recent genetic research suggests that ASD has strong genetic underpinnings, with heritability rates ranging between 40% and 90% (Persico & Napolini, 2003).

2. Atypical visual processing in ASD

In addition to these social deficits, ASD is often accompanied by atypical sensory processing (American Psychiatric Association, 2013). More specifically, a great amount of research has focused on visual processing strategies in individuals with ASD. Differences between individuals with and without ASD encompass a wide range of phenomena, from contrast detection, colour vision and motion perception to the perception of social stimuli (for an exhaustive review, see Simmons et al., 2009).

Although no clear consensus has been reached so far, atypical visual processing in ASD seems to be related to the interplay between local and global visual processing (Rinehart, Bradshaw, Moss, Brereton & Tonge, 2000). Two neurocognitive theories in ASD have focused on the relationship between local and global processing in ASD. A first influential theory is the Weak Central Coherence (WCC) theory (Frith & Happé, 1994). Central coherence refers to the ability to process information with the focus on the global aspects of this information, rather than on the specific details. Individuals with ASD were described as having a weaker central coherence, combined with a stronger focus on details (Happé & Frith, 2006). The second theory, the Enhanced Perceptual Functioning (EPF) hypothesis (Mottron, Dawson, Soulières, Hubert & Burack, 2006), states that individuals with ASD have an overall superior perceptual function compared to neurotypical individuals. Later versions of both theories describe differences between individuals with and without ASD in terms of a bias or preference for local instead of global processing, and not in terms of an impairment, since difficulties in global processing in ASD can be overruled by adjusting task instructions (for empirical evidence on this topic, see Koldewyn, Jiang, Weigelt & Kanwisher, 2013). Recently, a meta-analysis performed by Van der Hallen, Evers, Brewaeys, Van den Noortgate and Wagemans (2014) did not show a deficit, but rather a temporal delay in global processing in individuals with ASD. They did not found an enhanced local processing effect, providing evidence against the EPF-theory.

3. Perception of social stimuli in ASD

Since ASD is considered to be a social deficit by the DSM-5 and faces are considered to be the most social of visual stimuli, differences in face processing have been well investigated and discussed. Many of the social impairments in ASD, such as avoidance of eye contact and lower responses to emotional displays, are related to aspects of face processing or affect the skill to attend to and process facial information (Dawson, Webb & McPartland, 2005).

In the vast amount of literature that studied face processing in ASD, three major lines of work could be delineated, namely (1) the effect of local and global processing on face memory and face recognition, (2) category or prototype formation of faces and the facial after-effect and (3) social attention towards and saliency of certain facial features. In the next sections, we will discuss these different research topics briefly. Given the specific focus of our meta-analysis on preferential viewing patterns in ASD (research line 3), we will elaborate mostly on that aspect.

3.1 Local and global processing, face memory and face recognition

An exhaustive review by Weigelt, Koldewyn and Kanwisher (2012) showed that face memory was impaired in participants with ASD, in comparison to neurotypical individuals. Remarkably, no difference in performance was registered between individuals with and without ASD when facial stimuli were presented simultaneously. Therefore, they concluded that individuals with ASD mostly experience difficulties in face recognition when there is a clear memory-aspect to the task.

Inspired by neurocognitive frameworks such as WCC and EPF, researchers evaluated the strength of global face processing in individuals with ASD. After all, faces are strong Gestalts, and a balance between global and local processing is crucial for efficient face processing (Behrmann, Richler, Avidan & Kimchi, 2014). Joseph and Tanaka (2003) found that individuals with ASD do have certain deficiencies in holistic face recognition, and that they rely more on part-based face encoding and recognition strategies. However, in their review, Weigelt, Koldewyn and Kanwisher (2012) also evaluated whether the interplay between local and global strategies are different for individuals with ASD compared to neurotypical individuals. Different face markers that investigate the mechanisms of these local and global strategies have been put to the test, such as the face inversion effect and the Thatcher illusion. They concluded that evidence for a local processing strategy is insufficient, since features of typical face identity recognition are also present in individuals with ASD. This can be seen, for instance, in the presence of the inversion effect and of a certain sensitivity towards the Thatcher illusion

3.2 Face prototypes and face after-effects

A second line of work is related to the atypical prototype or category formation in individuals with ASD. The ability to abstract and represent categorical information with a central representation or prototype is a necessary cognitive ability for the categorization of faces. Gastgeb, Rump, Best, Minshew and Strauss (2009) defined a prototype as '*a representation of past information that depicts the average of variations within a category*' (p.1). Prototype formation is an important skill because it decreases memory load, allowing individuals to store one single representation of experienced items such as faces. Based on experience, this face prototype is continuously updated, which leads to the representation of the *average* face. As a result, attention towards the central tendency of all experienced exemplar-faces is stimulated, thereby ignoring the variability within a category (Gastgeb, Wilkinson, Minshew & Strauss, 2011). Research points to an impairment in the process of updating face prototypes in individuals with ASD, since it was observed that individuals with ASD may not be capable of abstracting a prototype, and therefore do not display the prototype effect (Gastgeb et al., 2009).

In addition, several studies suggest that after-effects are reduced in individuals with ASD. Face after-effects are defined as biased perceptions as a result of sensory adaptation to a certain stimulus (Fox & Barton, 2007). Adaptation refers to the ability to adapt to new information and experiences (Strobach & Carbon, 2013). Pellicano, Jeffery, Burr and Rhodes (2007) investigated face adaptation in children with ASD, using a discrimination task with two face identities with and without previous adaptation to opposite-identity faces, and found a significantly reduced after-effect in children with ASD (Pellicano et al., 2007).

3.3 Saliency of facial features

Since atypical looking behavior (e.g. abnormalities in eye contact) is one of the clinical characteristics of ASD, this phenomenon is widely investigated. Research evaluating social attention patterns and the (a)typical saliency of facial features in ASD is abundant.

The first studies in this area did not utilize eye-tracking to study the saliency of the different areas in a face in individuals with ASD. In his landmark study Langdell (1978) found that children with ASD were significantly better than controls at recognizing faces based on isolated mouth information. However, they were significantly worse if they had to rely on eye cues compared to the control group. A few decades later, Rutherford, Clements and Sekuler (2007) showed that individuals with ASD were worse than typically developing controls at detecting small displacements of the eyes. No differences were found between those with and without ASD when discriminations in the mouth region had to be made. These results seem to suggest that individuals with ASD use the information in the eyes region to a lesser extent, and that they demonstrate increased attention towards the mouth region, compared to neurotypical individuals. In the literature, this is known as the excess mouth/diminished eye gaze hypothesis (Falck-Ytter & von Hofsten, 2011). However, many inconsistencies arise in the literature. For instance, Bar-Haim, Shulman, Lamy and Reuveni (2006) did not find any differences between groups in their study. Comparing attentional allocation to the eyes and mouth while viewing static faces showed similar patterns; both groups looked more often at the eye region than at the mouth region when upright faces were shown. When images of inverted faces were shown, the probe detection was of the same speed, regardless whether the probe appeared nearby the eyes or the mouth.

The emergence of eye-tracking technologies provided new possibilities in investigating atypicalities in social attention in ASD (Ames & Fletcher-Watson, 2010), and research comparing eye-movements of persons with and without ASD has grown tremendously. In their pivotal study, Klin, Jones, Schultz, Volkmar and Cohen (2002) showed significant differences in viewing patterns between the ASD group and control group when watching dynamic social scenes: the control group fixated the eye region significantly more than the ASD group. In contrast, fixations on mouths, bodies and objects were twice as high in the ASD sample compared to the control group. Also Pelphrey and colleagues (2002), found that the scan paths of the ASD group tended to be disorganized, undirected and erratic. The ASD sample viewed the external features of the isolated faces longer, and the internal features (i.e. the nose, mouth and eyes) shorter compared to the control group. In addition, atypical viewing patterns can already be identified in two-year olds with ASD (Jones & Klin, 2013).

However, not all studies found evidence for these differences in viewing patterns between groups. Although some studies have indeed identified aberrant gaze patterns in individuals with ASD, it is important to remark that there are great differences in samples, stimuli, tasks and regions of interest, making generalization very challenging. The assumption that individuals with ASD rely preferentially on information from the mouth could not be generalized across task demands, stimuli and samples in the review of Falck-Ytter and von Hofsten (2011). Recently, Papagiannopoulou, Chitty, Hermens, Hickie and Lagopoulos (2014) conducted a meta-analysis regarding fixation durations on eyes and mouth regions in children with ASD in studies using eye-tracking. They conclude that children with ASD indeed show reduced gaze fixation towards the eye region. Again, no significant differences in terms of fixation towards the mouth region were revealed. Significant heterogeneity in the mouth fixation studies was put forward as an explanation for these non-significant results (Papagiannopoulou et al., 2014). In the literature, a diversity of moderators that could explain the discrepancies between studies can be identified.

Firstly, a variety of samples has been used in different studies. Children with autism were significantly worse at recognizing faces than the control group and the children with ASD had a diminished focus on faces in comparison to the control group (Yi et al., 2013). However, the same experimental paradigms in adults did not reveal any group differences (Pillai et al., 2014). In addition, Falck-Ytter and von Hofsten (2011) only found partial support for the reduced eye gaze and excess mouth gaze hypothesis in adolescents and adults. In children, however, most studies did not support this hypothesis.

Secondly, the differences in results could also be related to differences in task instructions. Klin et al. (2002) presented a free-viewing task, in which participants could watch a number of video clips without further instructions. In the study by Snow and colleagues (2011), a face recognition task was used: participants were asked to indicate whether they recognized the stimuli from a previous phase of the experiment by pressing a button. Both the ASD and the TD group appeared to have a preference for the eyes in comparison to other facial features in this study. Thus, it seems possible that when an instruction is present, the level of attention increases, diminishing between-group differences. The study of Birmingham, Cerf and Adolphs (2011) confirmed this assumption and could serve as an example of how task differences could lead to different results. They found that group differences in eye fixations were the greatest when the task demanded social attention.

Thirdly, a diversity in stimulus characteristics can be encountered when reviewing the literature on social attention. Hanley, McPhilips, Mulhem and Riby (2012) showed that at least some of these characteristics might be influential, as they found that group differences were more pronounced when ecologically valid images (i.e. faces in a social context) were used compared to isolated faces. The impact of several other stimulus characteristics on the differences between the ASD and the comparison group are worth considering. Stimuli could be static or dynamic, shown upright or inverted and fully or partially, offered in colour or in greyscale, with a neutral or emotional expression. In addition, the number of faces that are shown at the same time, the presentation time as well as the size of the stimuli could differ across studies. This heterogeneity precludes any definitive statements as to the generalizability of findings without further analysis.

4. Research goal and research questions

Results in research concerning social attention in ASD have been contradictory. Some findings showed that individuals with ASD tend to fixate less at the eye region and more at the mouth region, but other studies did not find any differences between groups. Different factors can contribute to these contradictory findings: the constitution of experimental groups, paradigms and stimuli characteristics, the inclusion and delineation of specific regions of interest and the choice of performance measures. The ambition of the present meta-analysis was to systematically examine the currently available empirical studies and to combine their results to quantify the evidence for atypical saliency of facial features in ASD, using formal meta-analytic techniques.

Although meta-analyses and reviews on the topic of visual social attention in ASD have been performed before (e.g. Falck-Ytter & von Hofsten, 2011; Guillon, Hadjikhani, Baduel & Rongé, 2014; Papagiannopoulou, Chitty, Hermens, Hickie & Lagoupoulos, 2014), the present meta-analysis can be a valuable addition to the already existing literature. Firstly, the encountered reviews focus on eye-tracking studies only, while we aim to include all studies that address the topic of saliency of facial features (such as for example the well-known study without eye-tracking of Rutherford, Clements & Sekuler, 2007). Secondly, the main objective of the previous reviews was to evaluate data in terms of the diminished eye/excess mouth gaze hypothesis. As the division of a face in different regions of interest can happen in several ways in the literature, and other regions of interest besides the eyes and mouth are often included (cf. Method section), we aspire to examine the saliency of facial features in relation to all possible regions of interest and divisions.

Glass (1976) defined meta-analysis as '*the analysis of analyses'* or *'the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings* (…) *a rigorous alternative to the casual, narrative discussions of research studies which typify our attempts to make sense of the rapidly expanding research literature.'* (p. 3). A meta-analysis is thus the synthesis of results from multiple studies in terms of effect sizes. In addition to evaluating the overall size of the effect, this meta-analysis aims at identifying the moderators that can explain the discrepancies in the literature. More concretely, we evaluated the effect of 9 moderator variables on the overall effect size.

METHOD

1. Literature search

We searched for English journal articles and reviews in the Web of Science and the PubMed database, using the following Boolean search term:

> 'Topic = (autis* OR ASD OR ASC OR asperger* OR PDD*)
> AND
> Topic = (face* OR facial)
> AND
> Topic = (((left visual field) OR (chimeric*) OR (configura* OR scrambl* OR part-based OR holistic OR featur* OR analytic* OR local OR global OR inver* OR upside* OR composite OR *whole* OR Thatcher*) OR (*spatial AND frequenc*) OR (memory OR recogni* OR label* OR identif* OR match* OR discriminat*) OR (template* OR prototyp* OR after-effect* OR categor*) OR (mouth* OR eye*)))'.

The first level of keywords covered the clinical group of interest: "autis*", "ASD", "ASC", "asperger" and "PDD". A second level of keywords set the key topic: "face*" and "facial". The last level of keywords included specific concepts in relation to our three research lines within face perception: "left visual field", "chimeric*", "configure*", "scramble*", "part-based", "holistic", "feature", "analytic*", "local", global", "inver*", "upside", "composite", "*whole*", "Thatcher", "spatial", "frequenc", "memory", "recogni*", "label", "indentif*", "match" and "discriminat*" for Local versus global face processing; "template*", "prototyp*", "after-effect*", "aftereffect*" and "categor*" for Category formation; and "mouth*" and "eye*" for the Saliency research line.This search resulted in 1778 articles in the Web of Science database, and another 361unique articles in PubMed. Furthermore, an e-mail alert for both databases was set. In total, 2621articles were found at the end date of 3 February 2015.

In addition, a manual search was performed, by checking the reference and citation lists of three important literature reviews (Falck-Ytter & Von Hofsten, 2011; Jemel, Mottron & Dawson, 2006; Weigelt, Koldewyn & Kanwisher, 2012) and of a number of key articles in the research on various aspects of face processing in ASD (de Gelder, Vroomen & van der Heide, 1991; Joseph & Tanaka, 2003; Klin, Jones, Schultz, Volkmar & Cohen, 2002; Langdell, 1978; Pellicano, Jeffery, Burr & Rhodes, 2007; Pelphrey et al., 2002; Tantam, Monaghan, Nicholson & Stirling, 1989). This complementary manual search led to the inclusion of two additional papers (de Gelder, Vroomen & van der Heide,1991; Freeth, Ropar, Mitchell, Chapman & Loher, 2011).

2. Inclusion and exclusion criteria

A set of inclusion and exclusion criteria was constructed to start the selection process of all relevant papers for the meta-analysis. A decision tree was set up, containing the following eight criteria:

1) The study is published in English and reported in a peer-reviewed journal.
2) The study addressed individuals with a clinical diagnosis of ASD as an experimental group. If the study encompassed family members or individuals with sub-clinical ASD characteristics, the paper was excluded.
3) The study included at least one non-clinical comparison group.
4) The study had an experimental design. Case-studies, reviews and intervention studies were excluded.
5) The study contained behavioral outcome measures, such as reaction times, accuracy levels or eye-movements patterns. Neural data (e.g., fMRI, ERP, ...) were not included in the present meta-analysis. However, articles were included if behavioral results were presented in addition to neural information.
6) The study addressed visual processing. If an article involved both visual and for example auditory information processing, only the data involving visual processing was included.
7) The study examined face perception. Studies that only addressed non-facial stimuli, such as for example objects, bodies or natural scenes, were excluded.
8) The content of the study addressing face perception in ASD and the visual processing task had to be relevant to one of the three research lines: (a) Local and global face processing, face memory and recognition, (b) Category formation and (c) Saliency of facial features. If, for instance, only emotion identification or gaze-following was evaluated, the study was excluded.

The abstracts of all the generated articles were read and categorized according to the eight selection criteria. Based on the abstracts, the articles were judged ‘To include’, ‘Not to include’ or ‘Undecided’. This judgement was provided by one of three researchers, all applying the same set of selection criteria. The inter-rater reliability between the three researchers was calculated based on 302 abstracts (202 articles from the Web of Science-search and 100 articles of PubMed) and showed an agreement in 92.11% of the cases, resulting in a Fleiss' Kappa of 88.17 which signifies a very high agreement between the raters.

In total, 2410 or 91.95% of the 2621 papers were false positives (i.e. 'Not to include'), and 211 were hits (i.e. 'To include'). The 211 selected studies were divided into the three research lines, with a majority of the studies focusing on local/global face processing, face discrimination and face memory (131 papers), with 18 papers discussing facial prototypes and 95 studies evaluating the saliency of facial features. One paper could fit into multiple categories. After thorough discussion we decided, based on pragmatic reasons and personal interests, to restrict the meta-analysis to the 95 articles that discuss the saliency of facial features for individuals with ASD. Of these 95 studies, another 38 papers were labelled as false positives upon closer inspection, because they did not correspond as well to the topic of this meta-analysis as was initially thought based on the screening of their abstract. They were not coded and thus excluded from the meta-analysis.

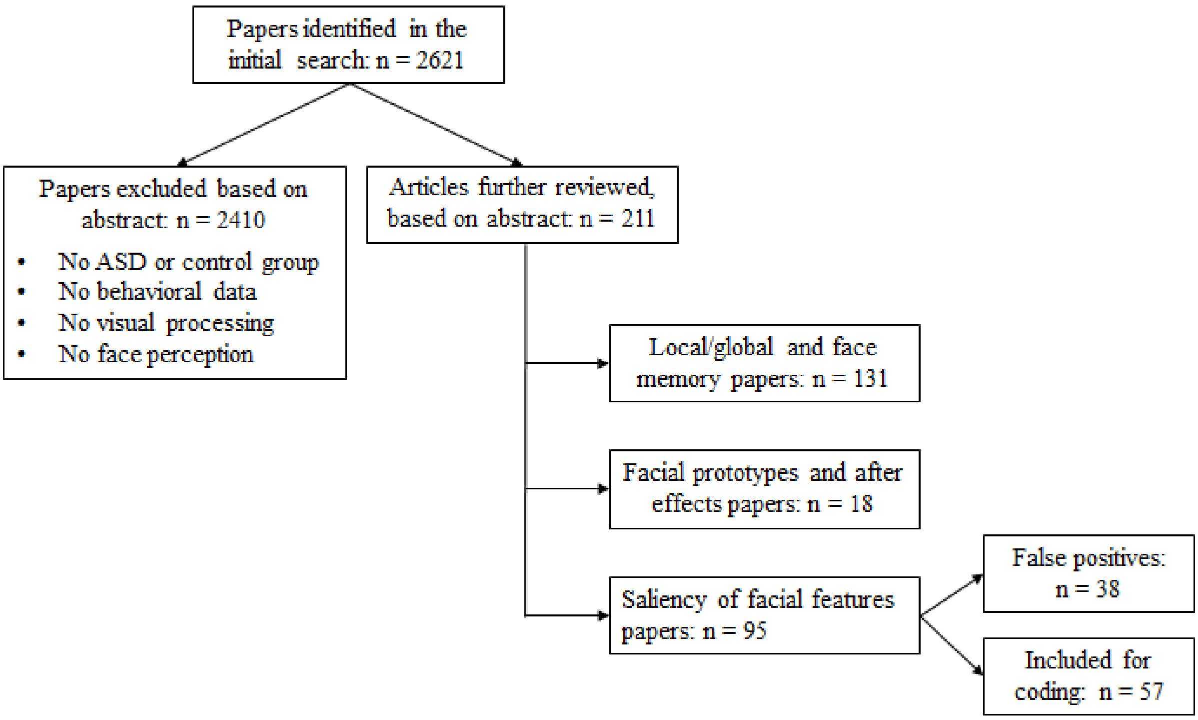

Figure 1. Selection process. This flow-chart displays the entire inclusion and exclusion process of searching for articles to include in this meta-analysis.

3. Coding of studies

For the remaining 57 studies, the following variables were coded by the first and second author:

(a) Author's details: the authors' last names, year of publication and country of first author were coded.

(b) ASD group: The type of ASD was categorized in five different categories: autistic disorder (AD), Asperger Syndrome (AS), Autism Spectrum Disorder (ASD), high-functioning autism (HFA) or Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS).If the experimental group included more than one type of ASD and study results were reported separately for each type, these experimental groups were coded separately. Else, the experimental group was coded as 'ASD'. It was also registered whether participants of the experimental group were formally diagnosed according to an appropriate diagnostic test - such as the Autism Diagnostic Observation Schedule (ADOS) or the Autism Diagnostic Interview (ADI) - or by clinical assessment by an expert.

(c) Comparison group: for the non-clinical control group it was coded how they were matched to the experimental group e.g. based on IQ, age, gender. Other clinical groups such as ADHD, schizophrenics, etc. were discarded. Additional measures that were used to screen the control group participants (e.g. the Social Communication Questionnaire) were also noted.

(d) Group size: for the experimental and the control group, the group size was registered.

(e) Gender: for each experimental and control group, the number of boys and girls was noted. Afterwards, a categorical variable taking the gender-ratio of both the experimental and control group into account was made: (1) both all-male groups (+85% males), (2) both all-female groups (+85 % females), (3) both mixed groups, gender-ratio matched and (4) both mixed groups, gender-ratio non-matched.

(f) Age: the minimum, maximum, average and standard deviations of the age of both participant groups was coded. Afterwards, a categorical variable of age was constructed with the following levels: (1) younger than 6 years old, (2) between 6 and 12 years old, (3) between 12 and 18 years old, (4) between 18 and 25 years old and (5) older than 25 years old.

(g) Intelligence level for both participant groups: minimum, maximum, average IQ-measures (e.g. FSIQ, VIQ, PIQ), standard deviations and the test through which they were obtained (e.g. WISC, WAIS, Raven Matrices) were coded. If an article only reported the mental age of both participants groups, this was converted to IQ-scores by using the following formula: $\frac{\text{Developmental Age}}{\text{Chronological Age}}$ x 100. For the analyses, a categorical variable for all IQ measures was constructed with the following levels: (1) < IQ 85, (2) between IQ 85 and IQ 115 and (3) > IQ 115.

(h) Experimental paradigm and task instructions: a distinction was made between tasks where participants received no instructions and could freely scan the faces, and task with certain task demands. If the paradigm included specific instructions for the participants, these were further categorized in:

a. Global task: tasks involving an evaluation based on the whole face image, e.g. a face discrimination task where two different faces are shown and participants have to discriminate whether the identity of both faces is the same or not.
b. Local task: tasks involving focus on local facial components, e.g. a discrimination task where participants have to decide whether two sets of eyes are identical or not (with explicit attention allocation towards the eye region when a whole face is shown).
c. Global task using local information: tasks involving a whole face image and where judgments are based on the whole face, but where it is necessary to take into account local information for that judgement, e.g. a face discrimination task with almost two identical faces, where participants have to detect small spatial displacements of the eyes and/or the mouth.

(i) Different characteristics of the experimental stimuli were coded:

a. Dynamic or static faces.
b. Gender of faces (male, female or mixed).
c. Emotional expression: neutral, emotional (specific emotional expression) or emotional (mixed).
d. Upright or inverted faces.
e. Full faces or face parts.
f. Colour or greyscale faces.

g. Isolated faces or faces in context (e.g., faces with body, human figures in social scene).
h. Size of the stimuli (visual ° and size on screen in pixels).
i. Number of faces on screen.
j. Presentation duration per trial (in milliseconds).

(j) Type of eye-tracker that was used.

(k) Region:

a. Face versus non-face regions (RegionFaces):
    i. Face, including hair, ears and forehead.
    ii. Background, being all non-face areas inside the stimulus, such as the persons' body and hands, objects.
    iii. Off screen.
b. Upper versus lower facial areas (RegionUpperLower):
    i. Upper (i.e. eye and forehead) region.
    ii. Lower (i.e. mouth and chin) region.
    iii. Middle (i.e. nose) region.
c. Internal versus external facial features (RegionIntExt):
    i. Internal facial features, consisted out of the core facial features of eyes, nose and mouth.
    ii. External facial features, consisted of the forehead, chin, cheeks and hair.

(l) Dependent variables:

a. Descriptive statistics: for the experimental and control group, average task performances, standard deviations and group sizes were coded.
b. Performance measures: dependent measures were expressed as accuracy scores (values in % correct), reaction times (times in milliseconds), number of fixations (raw or values in %), fixation durations (times in milliseconds), proportion viewing time (values in %), the proportional frequencies of made saccade paths (in %), the duration of the first fixation (in milliseconds) and the proportion of trials with an upward or downward gaze direction (in %) .
c. Test statistics: t and F values with the according degrees of freedom were collected when provided. Statistical values were coded as significant ($p \leq .05$) or non-significant ($p > .05$).

(m) Study results: The direction of effect was coded positively when that specific facial feature (e.g. the mouth region) was more salient for the ASD group compared to the control group, and negatively when the ASD group had less attention towards a specific region compared to the control group.

A complete overview of the detailed coding scheme and coding manual can be found using the following link: https://www.dropbox.com/sh/ftvgh3harro6ht4/AABLn4Tvs42WxFZmE7OtujYRa?dl=0.

4. Statistical analysis

A meta-analysis is an analysis of effect sizes. With all available descriptive statistics and test measures, the Hedges' g effect size was calculated (Equation 1). This measure expresses the standardized difference between the means of an experimental and control group by dividing the difference of the sample mean for the experimental group ($\bar{x}_E$) and the control group ($\bar{x}_C$) by the pooled sample standard deviation (s_p).

$$g = \frac{\bar{x}_E - \bar{x}_c}{s_p} \tag{1}$$

Hedges' g takes the size of the sample for each group explicitly into account and assigns a corresponding weight to each group. To determine these weights, the corresponding standard error ${\sigma^2}_{gj}$ was also computed. A positive Hedges' g implies that this specific region is more salient for the ASD group, while a negative Hedges' g expresses a less salient meaning of this region for the ASD group compared to the control group. For Hedges' g an effect size of 0.2 to 0.3 is regarded as a small effect, an effect size around 0.5 as a medium effect and from 0.8 and beyond it is regarded as a large effect. The calculation of g was done in Microsoft Excel.

Since the data of most studies resulted in more than one effect size, a third-level random effects model was used instead of the traditional second-level model, because it takes three sources of variation into account: the random sampling variation, the variation between studies and the variation between outcomes within one study. The simplest linear model to estimate g, a model without moderator variables, is given in Equation 2:

$$g_{jk} = \beta_0 + u_k + v_{jk} + e_{jk} \tag{2}$$

Element g_{jk} refers to the observed effect size for outcome j within study k. Element β_0 is the overall mean effect size, across all outcomes and studies. Element $u_{.k}$ refers to the deviation of the overall mean effect for study k. Element v_{jk} indicates the deviation of the effect for outcome j in study k from the mean effect in study k. The residual error e_{jk} incorporates the variance due to sampling fluctuation, indicating the deflection of the observed effect size from the population effect size for outcome j in study k. All three residuals are assumed to be independently and normally distributed with a mean of zero.

This basic model was extended by including some of the coded characteristics as predictors, which are typically referred to as 'moderating variables' in the context of a meta-analysis. All analyses were conducted with a significance level of 5%. The data analysis for this paper was generated using the statistical software of SAS 9.4 University edition (SAS Institute Inc., 2015). The implemented restricted maximum likelihood procedure was used to estimate all parameters of the three-level random effects models.

RESULTS

1. Effect size and publication bias

Of all studies that were coded for this meta-analysis, 46 articles included the necessary descriptive data to compute effect sizes. These 46 included studies yielded 367 observations or effect sizes, ranging from -7.48 to 26.24. Using a random effects analysis, we found an observed mean effect size of -0.1404 (SD = 2.4478) across all variables and regions of interest, with 95% confidence limits between -0.39 and 0.11. The between-study variance σ_v^2 was not significant (estimate = 0.06, z = 0.74, p = .2289), while the within-study variance σ_u^2 was significant (estimate = 2.44, z = 9.5, p < .0001), indicating that effect sizes varied significantly within (consistent with the idea of different expectations about group differences in the different regions of interest), but not across studies.

As an exploratory test of publication bias, we plotted the distribution of the 367 effect sizes as a function of their standard errors in a funnel plot (Figure 2). The vertical dotted line indicated the position of the overall mean effect size of -0.1404. Visual inspection showed a slightly asymmetrical funnel plot, with more positive effect sizes on the right side of the plot, which could be indicative of a publication bias. Therefore, we calculated the Kendall rank correlation coefficient. Kendall's tau did not significantly differ from 0 (τ = -0.0309, p = .3769), providing no indication for publication bias.

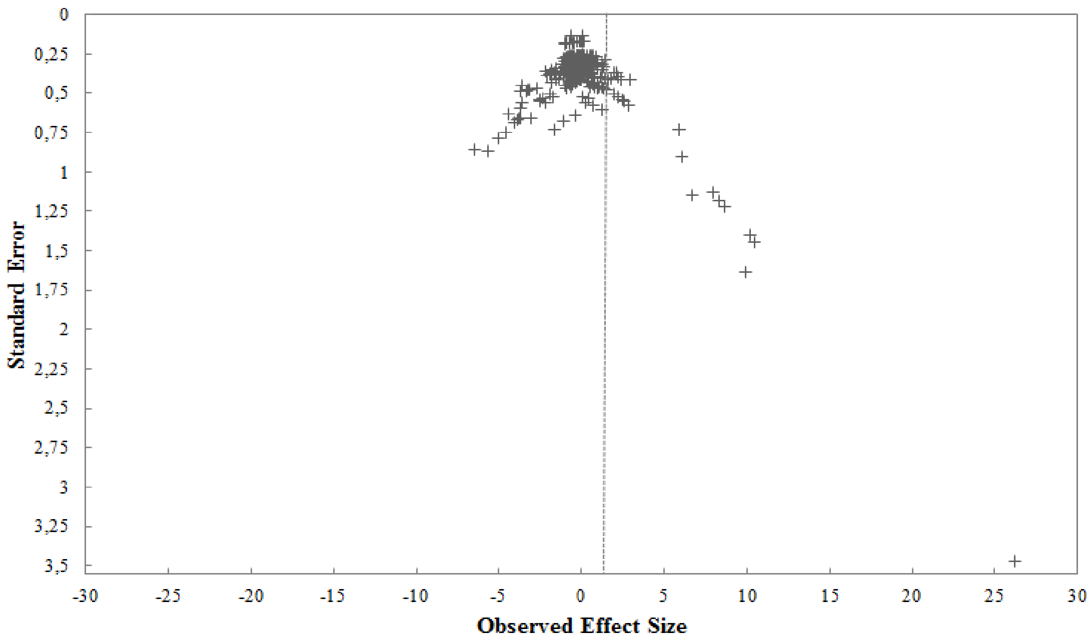

Figure 2. Funnel plot of the 367 effect sizes (g) in function of standard error.

2. Study descriptors

In the next paragraphs, the most important study descriptors are discussed. The first few variables (until paragraph *g. Intelligence level*) handle study or participant characteristics, which were the same within the entire study. Therefore results are reviewed in terms of studies. From then on, task characteristics are reviewed. Since one study can incorporate multiple task designs, stimuli or performance measures, the discussed descriptors then relate to the number of observations.

a. Year of publication

The publishing year of the 46 articles included in these meta-analysis ranges between 2002 and 2015. 28 articles or 60.87% of the studies are published in 2010 or later. In general, this meta-analysis thus includes quite recent research material.

b. Experimental participants

All studies reported how the experimental participants were selected and which diagnostic instruments were used. In 9 studies, the term ‘autism’ was used to denote the experimental group. Five studies included only individuals with high-functioning autism in their experimental group. In 4 studies, participants with Asperger syndrome were included. In 7 studies, the experimental group involved the broad term Autism Spectrum Disorder. In 20 studies, mixed groups were used, in which case the type of autism was also coded ‘ASD’. Only one article used an experimental group of which the participants were diagnosed with Pervasive Disorder-Not Otherwise Specified.

c. Control group

46 studies reported how their control participants are matched to the ASD participants. In 36 articles, chronological age is one of the matching factors. In 10 of these studies, the control group is solely matched on chronological age. In 28 studies, an IQ measure (VIQ, PIQ or FSIQ) or a combination of IQ measures was one of the matching variables. Only in 6 of these studies, an IQ measure was the only variable to match both groups. Gender was in 11 publications used as a matching factor, but always in combination with other factors. Other factors that were used for matching are ethnicity (n = 1) and education (n = 1).

d. Group size

The average number of participants was 19.67 for the ASD group (*SD* = 13.94) and 24.29 for the control group (*SD* = 21.32). The smallest sample contained 5 ASD participants and 5 control participants (Pelphrey et al., 2002). The study with the largest sample size included 85 ASD participants and 140 control participants (Wolf et al., 2008).

e. Gender

Two studies did not report the number of boys and girls in their participant groups (Bekele et al., 2014; Hanley, McPhillips, Mulhern & Riby, 2012). 13 studies included predominantly male groups (more than 85% males). Not one study consisted of all-female groups. Thirty studies used mixed gender groups, of which 27 used gender-ratio matched groups, and five of them did not. The gender ratio of the experimental group (1:7) is even more skewed than what is typically estimated in the ASD population (1:4; Elsabbagh et al., 2012), which was probably due to practical difficulties in recruiting female participants with ASD.

f. Age

The mean age of the ASD group was 16 years and 5 months (*SD* = 5 years and 3 months), which was equal to the average age for the control group: 16 years and 3 months (*SD* = 4 years and 4 months). The most frequent age category for both participants group was the age group between 12 and 18 years old. For all but two studies, we classified participants in both the ASD and the control group in the same age group. For the study of Grossman, Steinhart, Mitchell and McIlvane (2015) the ASD group was one age group younger than the control group (27 observations), for the study of Riby and Hancock (2008) the ASD group was two age categories older than the control group (2 observations).

g. Intelligence level

The mean VIQ (*M* =93.79, *SD* = 15.92), PIQ (*M* = 91.09, *SD* = 13.14) and FSIQ (*M* = 99.05, *SD* = 13.15) scores of the ASD group were on average 8 points lower than the IQ scores of the control group (VIQ: *M* = 105.74, *SD* = 12.99; PIQ: *M* = 101.12, *SD* = 12.12; FSIQ: *M* = 103.95, *SD* = 11.31). The most common group for both the ASD and control sample and for all IQ measures was the group with an IQ between 85 and 115.

h. Experimental paradigm and task instructions

Of the 367 observations, 157 effect sizes (42.78%) involved a passive viewing task, where the participants could freely scan the facial stimuli, and 210 observations (57.22%) involved experimental paradigms with a specific task instruction. Of these experimental tasks with an explicit instructions, 86 observations (40.95%) involved a global task, 60 (28.57%) observations involved a local task and 64 observations (30.48%) involved a global task using local information. Of the included 46 studies, three of them reported more than one type of experimental task.

i. Stimuli characteristics

A majority of the experimental paradigms used full, upright and static faces as experimental stimuli, yielding 333, 347 and 307 observations respectively. 57 observations included dynamic faces, 16 inverted faces and 28 effect sizes related to face parts.

j. Region

With reference to the face versus non-face regions, 315 effect sizes related to the total facial area, 36 to the background area and 7 to off screen regions. Concerning the upper versus the lower face parts, 129 observations regarding the eye region and 105 effect sizes regarding the mouth region were included. Only 19 observations concerned the nose region. As to the internal versus external facial regions, much more observations related to the internal regions (268) than to the external face regions (25).

k. Performance measures

Of the 367 observations, 86 involved an accuracy measure (in %), 8 encompassed reaction times (in milliseconds), 55 included the number of fixations made (7 raw, 48 in %), 202 involved the fixation duration (131 in milliseconds, 71 in %), 10 included the proportional frequencies of saccade paths made (in %), 4 encompassed the first fixation (in milliseconds) and 2 involved the proportion of trials with an upward or downward gaze direction (in %). Since all these different dependent variables can be interpreted as a measure of saliency, and since the analysis on fixation duration alone yielded the same results as analysis on all variables, the effect sizes of all dependent variables were combined in this meta-analysis

Table 1.

Data for Meta-Analysis.

Authors	Year	Gender	Age		VIQ		PIQ		Task	Stimuli			Measure	Region			*g*	SE	Prec
			ASD	**TD**	**ASD**	**TD**	**ASD**	**TD**		**D/S**	**U/I**	**F/P**		**F/N**	**U/L**	**I/E**			
Andersen, Colombo & Shaddy	2006	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	S	U	F	FixDur (ms)	F		I	6	0.28	3
	2006	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	S	U	F	FixDur (ms)	F		E	0.44	0.28	3
Bal et al.	2010	Mix (n-m)	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (%)	F		E	0.74	0.11	8
Bar-Haim, Shulman, Lamy & Reuveni	2006	Male	6-12 y	6-12 y					Local	S	I	F	RT (ms)	F	U	I	0.25	0.17	5
	2006	Male	6-12 y	6-12 y					Local	S	I	F	RT (ms)	F	L	I	0.37	0.17	5
	2006	Male	6-12 y	6-12 y					Local	S	U	F	RT (ms)	F	U	I	0.47	0.17	5
	2006	Male	6-12 y	6-12 y					Local	S	U	F	RT (ms)	F	L	I	0.37	0.17	5
	2006	Male	6-12 y	6-12 y					Local	S	I	F	RT (ms)	F	U	I	0.65	0.18	5
	2006	Male	6-12 y	6-12 y					Local	S	I	F	RT (ms)	F	L	I	0.58	0.17	5
	2006	Male	6-12 y	6-12 y					Local	S	U	F	RT (ms)	F	U	I	0.75	0.18	5
	2006	Male	6-12 y	6-12 y					Local	S	U	F	RT (ms)	F	L	I	0.40	0.17	5
Bekele et al.	2014		12-18 y	12-18 y					Global	D	U	F	FixDur	F	L	I	-1	0.27	3
	2014		12-18 y	12-18 y					Global	D	U	F	FixDur	F	U	I	1	0.23	4
	2014		12-18 y	12-18 y					Global	S	U	F	FixDur	F	L	I	-1	0.25	3
	2014		12-18 y	12-18 y					Global	S	U	F	FixDur	F	U	I	1	0.23	4
Best, Minshew & Strauss	2010	Mix (m)	18-25 y	18-25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	P	Acc (%)	F	L	I	0	0.13	7
	2010	Mix (m)	18-25 y	18-25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	P	Acc (%)	F	U	I	-1	0.16	6
	2010	Male	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	P	Acc (%)	F	L	I	0	0.12	8
	2010	Male	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	P	Acc (%)	F	U	I	0	0.12	8
Birmingham, Cerf & Adolphs	2014	Male	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Global	S	U	F	Viewtime (%)	F	U	I	0	0.32	3
	2014	Male	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Global	S	U	F	Viewtime (%)	B			0.70	0.33	3
	2014	Male	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Global	S	U	F	Viewtime (%)	F			1	0.36	2
Dalton et al.	2005	Male	12-18 y	12-18 y					Global	S	U	F	FixDur (ms)	F	U	I	0	0.17	5
	2005	Male	12-18 y	12-18 y					Global	S	U	F	FixDur (ms)	F	U	I	0	0.16	6
Falck-Ytter et al.	2010	Mix (m)	< 6 y	< 6 y					FV	D	U	F	FixDur (%)	F	L	I	0	0.14	7
	2010	Mix (m)	< 6 y	< 6 y					FV	D	U	F	FixDur (%)	F	U	I	0.35	0.14	7

Falkmer,	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	NumFix (%)	F	U	I	0	0.14	7
Bjällmark,	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	NumFix (%)	F	L	I	0.32	0.14	7
Larsson &	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	NumFix (%)	F		E	0.33	0.14	7
Falkmer	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	FixDur (ms)	F	U	I	0.80	0.15	6
	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	FixDur (ms)	F	L	I	0.22	0.31	3
	2011a	Mix (m)	> 25 y	> 25 y					FV	D	U	F	FixDur (ms)	F		E	0.50	0.14	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F	U	I	0	0.14	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F	U	I	0	0.13	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F	L	I	8	0.15	6
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F	L	I	0.18	0.13	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F		E	0.20	0.13	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F		E	0.62	0.14	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F	U	I	0	0.15	6
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F	U	I	0.57	0.14	6
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F	L	I	1	0.36	2
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F	L	I	1	0.17	5
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F		E	0.60	0.14	7
	2011a	Mix (m)	> 25 y	> 25 y					Global	S	U	F	FixDur (ms)	F		E	0.61	0.14	7
Falkmer,	2011b	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F	L	I	-3	0.21	4
Bjällmark,	2011b	Mix (m)	> 25 y	> 25 y					Global	S	U	F	NumFix (%)	F		E	-1	0.10	9
Larsson &	2011b	Mix (m)	> 25 y	> 25 y					Local	S	U	P	NumFix (%)	F	U	I	-1	9	10
Falkmer	2011b	Mix (m)	> 25 y	> 25 y					Local	S	U	P	NumFix (%)	F	L	I	-2	0.17	5
	2011b	Mix (m)	> 25 y	> 25 y					Local	S	U	P	FixDur (ms)	F		E	0.66	8	11
	2011b	Mix (m)	> 25 y	> 25 y					Local	S	U	P	FixDur (ms)	F	L	I	0	8	11
Falkmer,	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	P	Acc (%)	F	U	I	-1	9	10
Larsson,	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	P	Acc (%)	F	U	I	0	8	11
Bjällmark &	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	F	NumFix (%)	F	L	I	-2	0.13	7
Falkmer	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	F	NumFix (%)	F	U	I	-1	8	11
	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	F	NumFix (%)	F		E	1	8	11
	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	P	NumFix (%)	F	L	I	-2	8	11
	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	P	NumFix (%)	F	U	I	-6	8	11
	2010	Mix (m)	> 25 y	> 25 y					G w/ L	S	U	P	NumFix (%)	F		E	3	8	11
Freeth,	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	Viewtime (%)	F			0.18	8	11
Chapman,	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	Viewtime (%)	F			0	8	11
Ropar &	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	FirstFix (ms)	F			-9	8	11
Mitchell	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	FirstFix (ms)	F			0	8	11
	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	FirstFix (ms)	B			0.21	8	11
	2009	Mix (m)	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	S	U	F	FirstFix (ms)	B			0.79	8	11

Fujisawa et al.	2014	Mix (n-m)	< 6 y	< 6 y			FV	D	U	F	FixDur (%)	F	L	I	0	8	11
	2014	Mix (n-m)	< 6 y	< 6 y			FV	D	U	F	FixDur (%)	F	U	I	0	8	11
	2014	Mix (n-m)	< 6 y	< 6 y			FV	D	U	F	FixDur (%)	F		E	0.41	8	11
Grossman, Steinhart, Mitchell & McIlvane	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	B			-1	7	13
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	B			0.59	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	F	L	I	-1	7	13
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	F	U	I	0	7	13
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	FixDur (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	B			0.85	7	13
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	B			0.12	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	F	L	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	G w/ L	S	U	F	NumFix (%)	F	U	I	0.15	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	B			0.79	7	13
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	B			0.58	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	F	L	I	0	7	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	-4	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	0	7	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	B			0.51	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	B			-7	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	F	L	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	F	U	I	0	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	F	U	I	-7	6	14
	2015	Mix (m)	6-12 y	12-18y	85 – 115	85 – 115	Global	S	U	F	NumFix (%)	F	U	I	-6	6	14
Hanley, Philips, Mulhern & Riby	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	U	I	0	0.13	7
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	U	I	0	0.13	7
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F			0	0.13	7
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	L	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	M	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	M	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F	L	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	F		I	0.44	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	B		I	0.63	0.12	8
	2012		18-25 y	18-25 y			FV	D	U	F	FixDur (ms)	B		I	0.52	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	L	I	0	0.13	7
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	U	I	0	0.13	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	L	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	M		0	0.12	8

	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	L	I	0	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	M	I	-9	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F		I	-7	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	U		4	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	M		9	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F	U		0.10	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F			0.31	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	F			0.50	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	B			0.61	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	B			0.61	0.12	8
	2012		18-25 y	18-25 y			FV	S	U	F	FixDur (ms)	B			0.65	0.13	7
Hernandez et al.	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-5	0.74	1
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-5	0.62	1
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-4	0.56	1
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-4	0.47	2
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-3	0.44	2
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	U	I	-3	0.43	2
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	-3	0.43	2
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	-2	0.30	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	-2	0.30	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	-1	0.25	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	-1	0.21	4
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	M	I	0.68	0.20	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	-2	0.30	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	-2	0.28	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	0	0.20	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	0	0.19	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	0	0.19	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F	L	I	0	0.19	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	0.70	0.20	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	0.79	0.20	5
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	1	0.21	4
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	1	0.21	4
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	1	0.22	4
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	F		E	1	0.23	4
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			1	0.25	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			2	0.27	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			2	0.29	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			2	0.30	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			2	0.33	3
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	B			6	0.82	1
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	O			7	1	0.78
	2009	Male	18-25 y	18-25 y	85 – 115	85 – 115	FV	S	U	F	FixDur (ms)	O			8	1	0.72

	2009	Male	18-25 y	18-25 y	85 – 115		85 – 115		FV	S	U	F	FixDur (ms)	O			8	1	0.67
	2009	Male	18-25 y	18-25 y	85 – 115		85 – 115		FV	S	U	F	FixDur (ms)	O			10	1	0.51
	2009	Male	18-25 y	18-25 y	85 – 115		85 – 115		FV	S	U	F	FixDur (ms)	O			10	2	0.48
	2009	Male	18-25 y	18-25 y	85 – 115		85 – 115		FV	S	U	F	FixDur (ms)	O			26	12	8
Irwin & Brancazio	2014	Mix (m)	6-12 y	6-12 y					G w/ L	D	U	F	FixDur (ms)	F	L	I	0	0.22	4
	2014	Mix (m)	6-12 y	6-12 y					G w/ L	D	U	F	FixDur (ms)	F	L	I	0	0.21	4
	2014	Mix (m)	6-12 y	6-12 y					G w/ L	D	U	F	FixDur (ms)	F		E	0.52	0.21	4
	2014	Mix (m)	6-12 y	6-12 y					G w/ L	D	U	F	FixDur (ms)	F		E	0.74	0.21	4
Johnels, Gillberg,, Falck-Ytter & Miniscalco	2014	Mix (m)	< 6 y	< 6 y					FV	D	U	F	FixDur (%)	F	L	I	0	0.13	7
	2014	Mix (m)	< 6 y	< 6 y					FV	D	U	F	FixDur (%)	F	U	I	0	0.13	7
	2014	Mix (m)	< 6 y	< 6 y					FV	D	U	F	FixDur (%)	F		E	1	0.16	6
Jones, Carr & Klin	2008	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	D	U	F	FixDur (%)	F	L	I	0.10	0.10	9
	2008	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	D	U	F	FixDur (%)	F	U	I	-1	0.12	8
	2008	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	D	U	F	FixDur (%)	O			0.19	9	10
	2008	Mix (m)	< 6 y	< 6 y	< 85	85 – 115	< 85	85 – 115	FV	D	U	F	FixDur (%)	B			0.54	9	10
	2008	Mix (m)	< 6 y	< 6 y	< 85	85 - 115	< 85	85 - 115	FV	D	U	F	FixDur (%)	B			0.59	9	10
Kirchner, Hatri, Heekeren & Dziobek	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F			0	0.11	9
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F			0	0.10	9
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F	U	I	0	9	10
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F	U	I	0	9	10
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F	L	I	0	9	10
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			Global	S	U	F	FixDur (%)	F	L	I	0	9	10
Kliemann, Dziobek, Hatri, Steimke & Heekeren	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	U	I	0	0.17	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	L	I	0	0.17	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	U	I	0	0.18	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	L	I	0	0.19	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	U	I	0	0.19	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	L	I	0	0.17	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	U	I	0	0.18	5
	2010	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115			G w/ L	S	U	F	FixDur (ms)	F	L	I	0	0.18	5
Klin, Jones, Schultz, Volkmar & Cohen	2002	Male	12-18 y	12-18 y	85 – 115	85 – 115			FV	D	U	F	FixDur (ms)	F	U	I	-3	0.36	2
	2002	Male	12-18 y	12-18 y	85 – 115	85 – 115			FV	D	U	F	FixDur (ms)	F	U	I	1	0.16	6
	2002	Male	12-18 y	12-18 y	85 – 115	85 – 115			FV	D	U	F	FixDur (ms)	F	L	I	1	0.17	5
	2002	Male	12-18 y	12-18 y	85 – 115	85 – 115			FV	D	U	F	FixDur (ms)	F	L	I	1	0.17	5
Louwerse et al.	2013	Male	12-18 y	12-18 y					FV	S	U	F	FixDur (%)	F	U	I	0	6	16

McPartland,	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	U	F	FixDur (ms)	F	L	I	0	0.14	7
Webb, Keehn &	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	U	F	FixDur (ms)	F	U	I	0.46	0.14	7
Dawson	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	U	F	NumFix (%)	F	L	I	0	0.14	7
	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	U	F	NumFix (%)	F	U	I	0.18	0.14	8
	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	I	F	FixDur (ms)	F	L	I	0.22	0.14	7
	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	I	F	FixDur (ms)	F	U	I	0.47	0.14	7
	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	I	F	NumFix (%)	F	L	I	0	0.14	7
	2011	Mix (m)	12-18 y	12-18 y			> 115	> 115	FV	S	I	F	NumFix (%)	F	U	I	8	0.14	7
Mercadante et al.	2006	Male	12-18 y	12-18 y					FV	S	U	F	NumFix (raw)				-3	0.43	2
	2006	Male	12-18 y	12-18 y					FV	S	U	F	NumFix (raw)				-2	0.32	3
Neumann, Spezio,	2006	Male	18-25 y	18-25 y					G w/ L	S	U	P	FixDur (ms)	F	U	I	-7	1	0.63
Piven & Adolphs	2006	Male	18-25 y	18-25 y					G w/ L	S	U	P	FixDur (ms)	F	L	I	9	2	0.38
Pelphrey et al.	2002	Male	> 25 y	> 25 y	> 115		85 – 115		FV	S	U	F	NumFix (%)	F	U	I	-1	0.53	1
	2002	Male	> 25 y	> 25 y	> 115		85 – 115		FV	S	U	F	NumFix (%)	F	L	I	-1	0.46	2
	2002	Male	> 25 y	> 25 y	> 115		85 – 115		FV	S	U	F	NumFix (%)	F	M	I	0	0.41	2
Riby, Hancock,	2013	Mix (m)	6-12 y	6-12 y					Global	S	U	F	FixDur (ms)	F			0	9	10
Jones & Hanley	2013	Mix (m)	6-12 y	6-12 y					Global	S	U	F	FixDur (ms)	F	U	I	0	9	10
	2013	Mix (m)	6-12 y	6-12 y					Global	S	U	F	FixDur (ms)	F			-2	0.17	6
	2013	Mix (m)	6-12 y	6-12 y					Global	S	U	F	FixDur (ms)	F	U	I	-1	0.11	8
Riby,	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			Local	S	U	P	Acc (%)	F	L	I	-1	0.14	7
Doherty-	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			Local	S	U	P	Acc (%)	F	L	I	0	0.10	9
Sneddon &	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	P	Acc (%)	F	U	I	-2	0.15	6
Bruce	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	P	Acc (%)	F	L	I	-2	0.15	6
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	U	I	-1	0.13	7
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	L	I	0	0.11	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	L	I	0	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	L	I	0	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	L	I	0.26	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	U	I	-1	0.13	7
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	L	I	0	0.11	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	U	I	0	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	U	I	0	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	L	I	0.32	0.10	9
	2009	Mix (m)	12-18 y	6-12 y	< 85	85-115			G w/ L	S	I	F	Acc (%)	F	L	I	0.63	0.10	9
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			Local	S	U	P	Acc (%)	F	U	I	-3	0.23	4
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			Local	S	U	F	Acc (%)	F	L	I	-1	0.15	6
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			Local	S	U	F	Acc (%)	F	U	I	-1	0.14	6
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	P	Acc (%)	F	U	I	-1	0.14	7

	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	U	I	-3	0.24	4
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	U	I	-3	0.23	4
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	U	I	-1	0.13	7
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	U	I	-1	0.12	8
	2009	Mix (m)	12-18 y	12-18y	< 85	85-115			G w/ L	S	U	F	Acc (%)	F	L	I	0	0.11	9
Riby & Hancock	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (%)	F	U	I	-6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (%)	F	L	I	-6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	F		I	6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	B			6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	B			6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	B			6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	B			-2	0.17	5
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	F		I	-2	0.17	5
	2009	Mix (m)	12-18 y	12-18 y					FV	D	U	F	FixDur (ms)	F	U	I	-2	0.17	5
	2009	Mix (m)	12-18 y	12-18 y					FV	S	U	F	FixDur (%)	B			1	0.12	8
	2009	Mix (m)	12-18 y	12-18 y					FV	S	U	F	FixDur (%)	B			6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	S	U	F	FixDur (%)	F	L	I	6	0.56	1
	2009	Mix (m)	12-18 y	12-18 y					FV	S	U	F	FixDur (%)	F		I	-2	0.17	5
Rice, Moriuchi, Jones & Klin	2012	Mix (m)	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (%)	F	U	I	0	6	14
	2012	Mix (m)	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (%)	F	L	I	0	6	14
	2012	Mix (m)	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (%)	B			0.85	7	14
	2012	Mix (m)	6-12 y	6-12 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (%)	B			1	8	12
Rutherford, Clements & Sekuler	2007	Male	18-25 y	18-25 y	85 – 115	85 – 115	85 – 115	85 – 115	G w/ L	S		F	Acc (%)	F	L	I	2	0.12	8
	2007	Male	18-25 y	18-25 y	85 – 115	85 – 115	85 – 115	85 – 115	G w/ L	S		F	Acc (%)	F	U	I	0.88	0.13	7
Snow et al.	2011	Mix (m)	12-18 y	12-18 y					Global	S	U	F	NumFix (%)	F	U	I	0	9	10
	2011	Mix (m)	12-18 y	12-18 y					Global	S	U	F	NumFix (%)	F	M	I	0.11	9	10
	2011	Mix (m)	12-18 y	12-18 y					Global	S	U	F	NumFix (%)	F	L	I	0.11	9	10
Speer, Cook, McMahon & Clark	2007	Male	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (ms)	F	U	I	-1	0.19	5
	2007	Male	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (ms)	B			0.49	0.17	5
	2007	Male	12-18 y	12-18 y	85 – 115	85 – 115	85 – 115	85 – 115	FV	D	U	F	FixDur (ms)	B			0.81	0.18	5
Sterling et al.	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	U	I	-1	0.13	7
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	U	I	-1	0.13	7
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	L	I	0	0.11	8
	2008	Mix (m	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	L	I	-2	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	L	I	4	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (%)	F	L	I	7	0.11	8

	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	NumFix (%)	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	NumFix (%)	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	NumFix (%)	F	L	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	NumFix (%)	F	L	I	0	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	NumFix (%)	F	L	I	-2	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (ms)	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (ms)	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (ms)	F	L	I	0.10	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	FixDur (ms)	F	L	I	0.15	0.11	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	RawNumFix	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	RawNumFix	F	U	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	RawNumFix	F	L	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	RawNumFix	F	L	I	0	0.12	8
	2008	Mix (m)	18-25 y	18-25 y					FV	S	U	F	RawNumFix	F	L	I	0	0.12	8
Tanaka et al.	2012	Mix (n-m)	6-12 y	6-12 y					Local	S	U	P	Acc (%)	F	U	I	0	3	32
	2012	Mix (n-m)	6-12 y	6-12 y					Local	S	U	P	Acc (%)	F	U	I	-6	3	33
	2012	Mix (n-m)	6-12 y	6-12 y					Local	S	U	P	Acc (%)	F	L	I	-8	0.03	33.25
	2012	Mix (n-m)	6-12 y	6-12 y					Local	S	U	P	Acc (%)	F	L	I	1	3	33
	2012	Mix (n-m)	6-12 y	6-12 y					G w/ L	S	U	F	Acc (%)	F	U	I	-0.43	3	32.49
	2012	Mix (n-m)	6-12 y	6-12 y					G w/ L	S	U	F	Acc (%)	F	U	I	0	0.03	32
	2012	Mix (n-m)	6-12 y	6-12 y					G w/ L	S	U	F	Acc (%)	F	L	I	0.17	3	33
	2012	Mix (n-m)	6-12 y	6-12 y					G w/ L	S	U	F	Acc (%)	F	L	I	8	3	33.21
Tottenham et al.	2013	Mix (n-m)	12-18 y	12-18 y	85 – 115	85 – 115			FV	S	U	F	PropTrials	F	U	I	0	6	14
	2013	Mix (n-m)	12-18 y	12-18 y	85 – 115	85 – 115			FV	S	U	F	PropTrials	F	U	I	0	6	15
Wallace, Coleman & Bailey	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	-1	0.19	5
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	-1	0.17	5
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	-1	0.15	6
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	0	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	0	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	-7	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.15	6
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.15	6
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.14	6
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.14	7

	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.14	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	0	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	3	0.13	7
	2008	Mix (m)	> 25 y	> 25 y	85 – 115	85 – 115	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F		I	0.87	0.15	6
Wilson, Pascalis	2007	Male	6-12 y	6-12 y	< 85				Local	S	U	P	Acc (%)	F		I	0	0.12	8
& Blades	2007	Male	6-12 y	6-12 y	< 85				Local	S	U	P	Acc (%)	F		E	-1.25	0.14	7
Wilson,	2012	Mix (m)	6-12 y	6-12 y					FV	S	U	F	FixDur (%)	F	U	I	0	0.20	4
Palermo &	2012	Mix (m)	6-12 y	6-12 y					FV	S	U	F	FixDur (%)	F		I	0	0.19	5
Brock	2012	Mix (m)	6-12 y	6-12 y					FV	S	U	F	FixDur (%)	F		E	0.40	0.19	5
Wolf et al.	2008		6-12 y	6-12 y					Global	S	U	F	Acc (%)	F		I	0	3	28
	2008		6-12 y	6-12 y					Global	S	U	F	Acc (%)	F		I	0	3	29
	2008		6-12 y	6-12 y					Global	S	U	P	Acc (%)	F	U	I	0	3	30
	2008		6-12 y	6-12 y					G w/ L	S	U		Acc (%)	F		I	0	3	30
	2008		6-12 y	6-12 y					G w/ L	S	U	P	Acc (%)	F		I	0	3	31
	2008		6-12 y	6-12 y					G w/L	S	U	P	Acc (%)	F	U	I	0	3	31
	2008		6-12 y	6-12 y					G w/ L	S	U		Acc (%)	F	L	I	0	3	32
	2008		6-12 y	6-12 y					G w/ L	S	U		Acc (%)	F	L	I	0	3	33
	2008		6-12 y	6-12 y					G w/ L	S	U		Acc (%)	F	U	I	0	3	33
	2008		6-12 y	6-12 y					Local	S	U	F	Acc (%)	F	L	I	0	1	54
	2008		6-12 y	6-12 y					Local	S	U	F	Acc (%)	F		I	9	1	56
Yi et al.	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	Acc (%)	F			-1	0.14	7
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	Acc (%)	F	U	I	-1	0.11	8
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	FixDur (ms)	F			-1	0.12	8
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	FixDur (ms)	F			0	0.11	9
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	0	0.11	8
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	0	0.10	9
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	L	I	0	9	10
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	9	9	10
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	L	I	0.23	0.10	9
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	M	I	0.25	9	10
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	M	I	0.49	0.10	9
	2013	Mix (m)	6-12 y	6-12 y			< 85	85 – 115	Global	S	U	F	FixDur (%)	F	U	I	0.51	0.10	9
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	Saccade (%)	F	U	I	0	0.11	9
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	Saccade (%)	F	U	I	0	0.11	9
	2013	Mix (m)	6-12 y	< 6 y			< 85	85 – 115	Global	S	U	F	Saccade (%)	F		I	0	0.11	9

	2013	Mix (m)	6-12 y	6-12 y	< 85	85 – 115	Global	S	U	F	Saccade (%)	F	U	I	0	0.10	9
	2013	Mix (m)	6-12 y	< 6 y	< 85	85 – 115	Global	S	U	F	Saccade (%)	F	U	I	0	0.10	9
	2013	Mix (m)	6-12 y	6-12 y	< 85	85 – 115	Global	S	U	F	Saccade (%)	F		I	0	0.10	9
	2013	Mix (m)	6-12 y	< 6 y	< 85	85 – 115	Global	S	U	F	Saccade (%)	F	L	I	0	0.10	9
	2013	Mix (m)	6-12 y	< 6 y	< 85	85 – 115	Global	S	U	F	Saccade (%)	F			0	0.10	9
	2013	Mix (m)	6-12 y	< 6 y	< 85	85 – 115	Global	S	U	F	Saccade (%)				0.60	0.10	9
	2013	Mix (m)	6-12 y	6-12 y	< 85	85 – 115	Global	S	U	F	Saccade (%)				2	0.16	6
Yi et al.	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (ms)	F	U	I	-3	0.23	4
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (ms)	F	U	I	-1	0.12	8
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (ms)	F	L	I	0.82	9	10
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (ms)	F	M	I	0.84	9	10
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (ms)	F		E	2	0.14	7
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	U	I	0	9	10
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	U	I	0	9	11
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	M	I	0.23	8	11
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	L	I	0.24	8	11
	2014	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F		E	0.62	9	10
Yi et al.	2015	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	U	I	0	8	11
	2015	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	U	I	0	7	12
	2015	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	L	I	0.10	7	12
	2015	Mix (m)	18-25 y	18-25 y	< 85	< 85	Global	S	U	F	FixDur (%)	F	M	I	0.35	7	12
Zürcher et al.	2013	Male	18-25 y	18-25 y	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	-3	0.31	3
	2013	Male	18-25 y	18-25 y	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	L	I	-6	0.73	1.37
	2013	Male	18-25 y	18-25 y	85 – 115	85 – 115	Local	S	U	F	Acc (%)	F	U	I	-4	0.40	2
	2013	Male	18-25 y	18-25 y	85 – 115	85 – 115	Local	S	I	F	Acc (%)	F	L	I	-2	0.21	4

Note. ASD = Autism Spectrum Disorder, TD = typically developing controls; Age = mean age; VIQ = verbal IQ; PIQ = performance IQ; Male = all-males groups; Mix (m) = 2 mixed groups, gender ratio matched; Mix (n-m) = 2 mixed groups, gender-ratio non-matched; FV = free viewing task; Global = global task; Local = local task; G w/ L = global task using local information; D = dynamic faces; S = static faces; U = upright faces; I = inverted faces; F = full face; P = face parts; F = face; B = background; O = off screen; U = upper region; L = lower region; M = mid region; I = internal facial features; E = external facial features; *g* = Hedges' *g* effect size; SE = standard error; Prec = precision.

3. The impact of region of interest as moderator

Three different ways to divide the face in distinctive regions of interest (ROI) were coded: face vs. non-face regions (RegionFaces), upper vs. lower facial regions (RegionUpperLower) and internal vs. external facial regions (RegionIntExt). We evaluated the effect sizes in these three types of ROI by means of three univariate analyses, including only the effect of each of these three moderators. An overview of the outcomes of tests for fixed effects and least squares mean estimates for every effect size in these models can be found in Table 2 (cf. Appendix A) and in the figures below.

Incorporating the RegionFaces moderator shows a significant effect for this variable ($F(2,345) = 99.41$, $p < .0001$). Further analyses suggested that the ASD group looks significantly more towards the background ($g = 1.64$; $t(195) = 6.79$, $p < .0001$) and off screen areas ($g = 6.74$; $t(355) = 10.62$, $p < .0001$) compared to the TD group. In contrast, facial regions appeared less salient for the ASD group than for controls, as indicated by the significant negative effect size ($g = -0.52$; $t(30.7) = -4.97$, $p = < .0001$). These results are visualized in Figure 3.

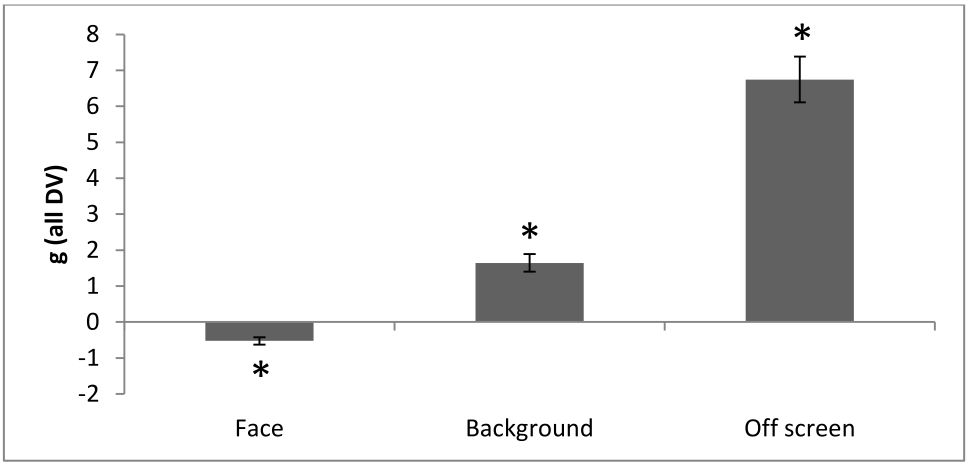

Figure 3. Effects of RegionFaces as moderator. Error bars represent the standard errors on the mean, * indicates $p < .05$.

The effect of the RegionUpperLower moderator was also significant ($F(2,152 = 8.11$, $p = .0005$). Individuals with ASD directed less social attention towards the upper face region ($g = -0.79$; $t(57.1) = -5.74$, $p < .0001$). However, this does not seem to imply increased saliency of the mouth region in the ASD sample, on the contrary: the effect size for the mouth region was also significantly negative ($g = -0.32$; $t(64.7) = -2.16$, $p = .0341$). The difference between the two participant groups on the nose region was not significant (g = -0.16, $t(160)$ = -0.57, p = .5690), as can be seen in Figure 4.

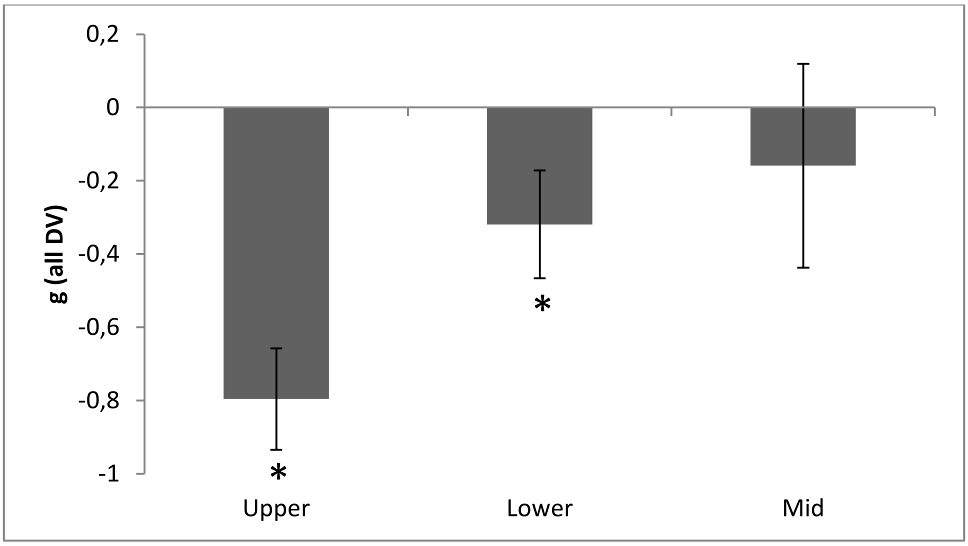

Figure 4. Effect of RegionUpperLower as moderator. Error bars represent the standard errors on the mean, * indicates p < .05.

Lastly, the effect of internal versus external facial regions was also significant ($F(1,211)$ = 39.35, p < .0002). Individuals with ASD have significantly less attention for the internal features of the face, i.e. the eyes, nose and mouth (g = -0.63; $t(40)$ = -5.38, p < .0001), and significantly more attention for the external facial features (g = 0.83; $t(182)$ = 3.48, p = .0006) (cf. Figure 5).

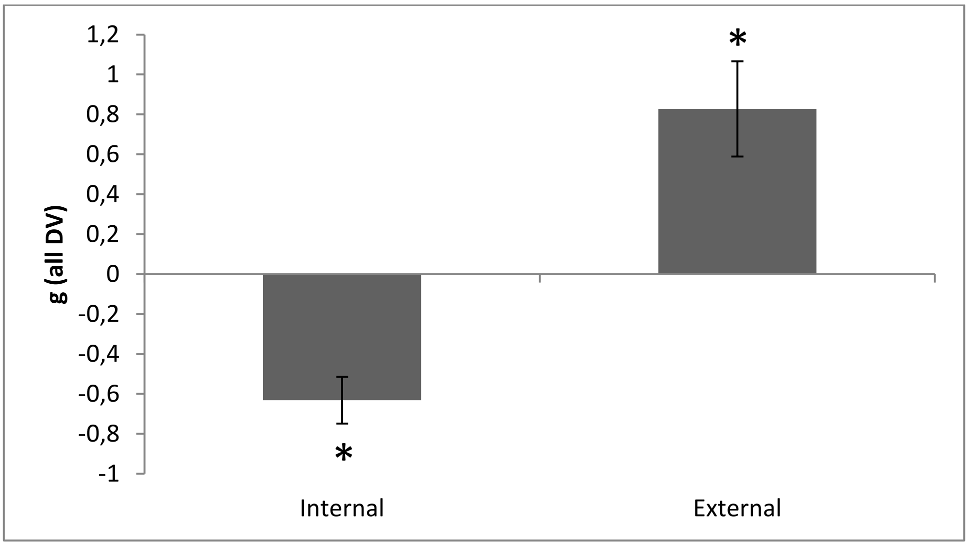

Figure 5. Effect of internal versus external facial regions. Error bars represent the standard errors on the mean, * indicates p < .05.

4. Impact of other moderator variables

The saliency of the above described facial regions was further analysed by including other moderator variables with information about participant characteristics, the task instructions, or stimulus characteristics. In these models, the discussed moderator was always combined with each of the three types of ROI and an interaction between the ROI and the moderator. For example, when the effect of Gender and RegionFaces were evaluated, the model incorporated main effects of the moderator variables Gender and RegionFaces, and an interaction effect between RegionFaces x Gender.

A complete overview of the effects of these moderators can be found in Table 3 (cf. Appendix B). The main effects of the different ROI moderators were already discussed in Section 3 (see above), and will only be further discussed in case of different findings. When a significant interaction effect between moderators was found, least squares means post-hoc *t*-test and simple mains effects were used to further investigate these interactions. These results are discussed in the sections below. All reported results refer to the estimated effect sizes, obtained by the least squares means method.

4.1 Participant characteristics

a. Gender

RegionFaces. The interaction effect between Gender and RegionFaces was significant ($F(2,247) = 18.37$, $p = < .0001$). Post-hoc simple mains analyses of this effects suggested significant differences in effect sizes between gender groups, but only in the face ($F(2,108) = 3.51$, $p = .0333$) and off screen regions ($F(1,255) = 30.56$, $p < .0001$). The face regions appeared to be significantly less salient for participants with ASD in the predominantly male groups ($g = -1.01$, $t(64.6) = -4.19$, $p < .0001$) and in the matched mixed gender groups ($g = -0.44$, $t(31.1) = -3.33$, $p = .0022$), but not in the non-matched mixed gender groups ($g = .09$, $t(160) = 0.25$, $p = .8063$). However, it should be noted that this is probably due to the small number of observations in this group. For the background and off screen regions, the effect sizes for this gender group could not be estimated due to an insufficient number of observations. ASD participants directed their attention significantly more towards the off screen region than control participants in the all-male group ($g = 8.55$, $t(311) = 11.50$, $p < .0001$), but not in the other groups. The difference in saliency for the background region seemed equal for all gender groups (cf. Table 4 and Figure 8, Appendix C).

RegionUpperLower. This model also yielded a significant interaction effect ($F(2,137) = 4.03$, $p = .0087$). A post-hoc simple mains analysis showed that this effect was manifested in the eye region only. The eye region was significantly more salient for control participants, but not in the non-matched mixed gender group ($p = .2987$). Again, the number of observations could play a role here. A visualization of these effects can be found in Table 5 and Figure 9, Appendix C.

RegionIntExt. A significant interaction effect was found for RegionIntExt x Gender ($F(2,153) = 5.25$, $p = .0062$). The direction of the effect sizes are in line with what was described above in terms of the internal and external facial regions; i.e. less saliency of the internal facial regions and more salient external facial regions for the ASD group. The most outstanding differences between the ASD and control participants reside in the all-male and matched mixed gender groups (cf. Table 6 and Figure 10, Appendix C).

b. Age (ASD and control group)

Secondly, the additional effect of age of the ASD group was investigated. Significant interaction effects were found in combination with all three ROIs: RegionFaces ($F(5,249) = 14.04$, $p < .0001$), RegionUpperLower ($F(7,142) = 2.43$, $p = 0.022$) and RegionIntExt ($F(4,211) = 6.54$, $p < .0001$). Especially for the background ($F(4,183) = 4.68$, $p = .0013$), off screen ($F(1,275) = 35.95$, $p < .0001$), eyes ($F(4,54.6) = 4.60$, $p = .0029$) and external regions ($F(4,162) = 3.13$, $p = .0163$), age seems to matter. Consistent across these ROIs, the differences between the ASD and control group were most pronounced in the age groups between 12 and 18 years old and between 18 and 25 years old. The effects for the other age groups mostly pointed in the same direction, but were not significant (cf. Appendix D).

The same analyses were done based on the age of the control group, which yielded the same findings.

c. IQ measures (ASD and control group)

Significant interaction effects were found for the RegionFaces ($F(2,132) = 6.90$, $p = .018$) and RegionIntExt ($F(1,96.2) = 8.06$, $p = .0055$) ROI in combination with verbal intelligence, and for RegionFaces ($F(2,126) = 4.65$, $p = .0112$) in combination with performance IQ. The results were very similar across both IQ measures: for the face, background, off screen (both for VIQ and PIQ) and mouth (only for VIQ) regions, the differences between the ASD and control group were the most pronounced for the participants with an IQ between 85 and 115. For the other IQ groups, the effects were not significant in these regions (cf. Appendices E & F). However, it should be noted the scarce number of observations for those intelligence groups might also play a role here. A similar analysis with the VIQ and PIQ measures of the control group was performed. There, some interaction effects could not be estimated. When estimated, these were not significant (see Table 3, Appendix B).

4.2 Task characteristics

a. Task instructions or free viewing

RegionFaces. A significant RegionFaces x Task interaction was found ($F(1,242) = 26.69$, $p < .0001$), implying that group differences on saliency of face versus non-face regions were influenced by the absence or presence of task instructions. When participants with ASD could freely scan the presented stimuli, they had a clear bias towards the background areas ($g = 2.16$, $t(163) = 7.57$, $p < .0001$). However, when participants received instructions, no significant difference in the saliency of the background area was found between participants with ASD and control participants ($g = 0.17$, $t(230) = 0.36$, $p = .7157$). For all facial areas together, no influence of task instructions was found. (cf. Figure 6 below and Table 13, Appendix G).

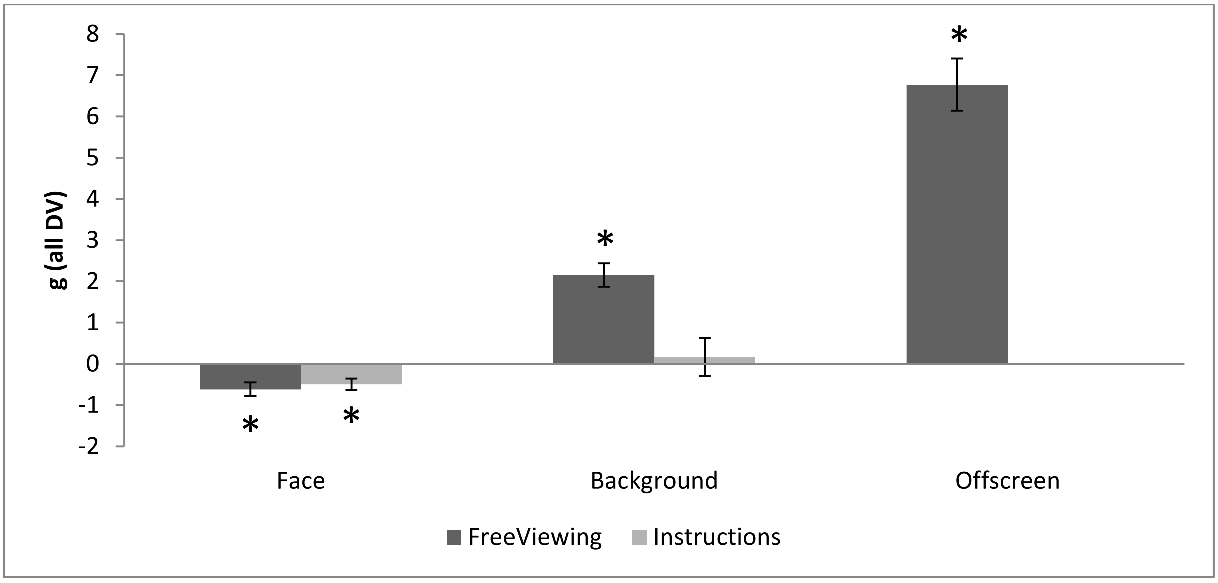

Figure 6. Effect of task instructions on the face versus non-face regions. Error bars represent the standard errors on the mean, * indicates $p < .05$.

RegionUpperLower. No significant interaction effect was found between RegionUpperLower and Task ($p = .1563$, cf. Table 3, Appendix B).

RegionIntExt. An interesting significant interaction effect for RegionIntExt x Task ($F(1,208) = 5.96$, $p = .0154$) was found. Simple mains analyses showed that the effect sizes for the external regions significantly depended upon the presence of task instructions ($F(1,206) = 5.30$, $p = .0233$). When instructions were provided, the external face region appears equally salient for the ASD and the control sample ($g = 0.34$; $t(188) = 1.07$, $p = .2849$). However, when participants could freely view the facial stimulus, the ASD sample spent significantly more attention towards the external region than controls ($g = 1.36$, $t(204) = 4.07$, $p < .0001$). No evidence for a differential effect of task instruction on the saliency of internal face regions was found ($F(1,71.6) = 0.15$, $p = .6982$). Internal face regions were significantly less salient for the ASD sample, both when instructions were provided ($g = -0.68$, $t(62.4) = -3.84$, $p = .0003$), and without task instructions ($g = -0.59$, $t(43.1) = -4.04$, $p = .0002$).

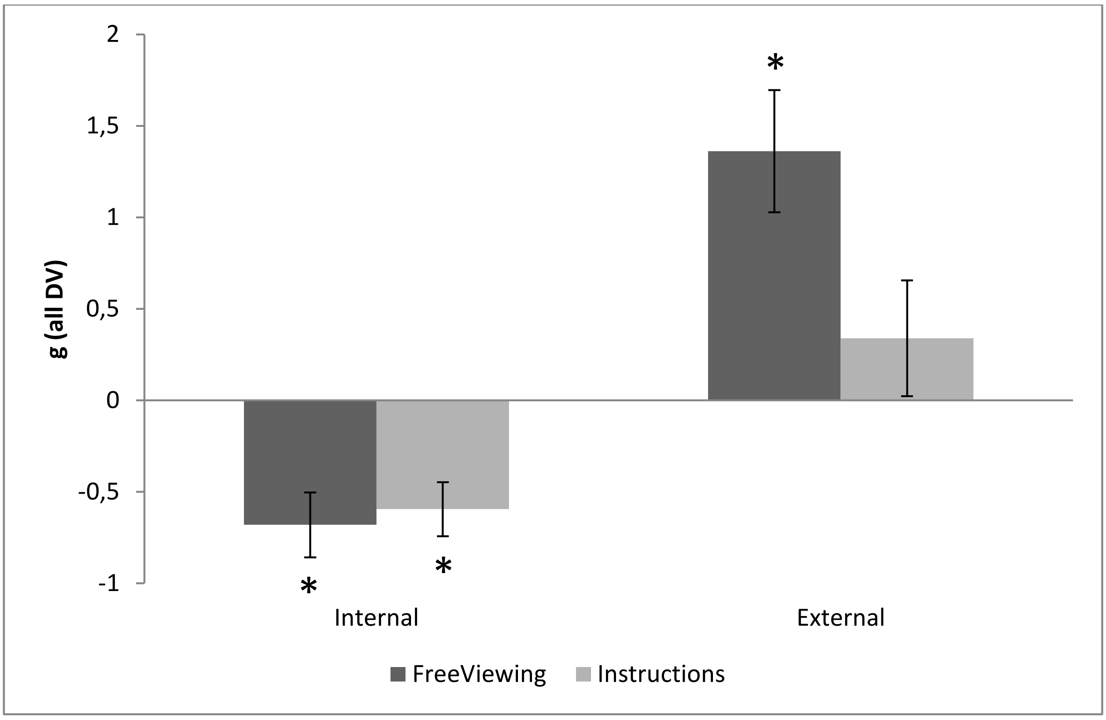

Figure 7. Effect of task instructions on the internal and external facial regions. Error bars represent the standard errors on the mean, * indicates $p < .05$.

b. A closer look at task instructions

In a second step, it was investigated whether the nature of the task instruction matters in terms of saliency of facial regions or not. No significant interaction effect was found when the Task_Instructions moderator was combined with the RegionUpperLower ROI, which was expected since the inclusion of explicit task instructions yielded no different results than in terms of saliency of this regions when participants could freely scan faces. Also in combination with RegionFaces no significant interaction effect was found (cf. Table 3, Appendix B).

The combination with the RegionIntExt ROI yielded a significant interaction ($F(2,161) = 7.88$, $p = .0005$). When experimental tasks explicitly allocate attention towards specific face regions, the preferential bias of the ASD group towards the external regions can be overcome, as these regions were now significantly less salient for the ASD group than for the control group ($g = -1.89$,$t(260) = -33.12$, $p = .0022$). However, the difference between the ASD and control group for the internal facial features remained significant ($p = .0022$; cf. Appendix H).

4.3 Stimuli characteristics

Only for static versus dynamic faces and RegionFaces a significant interaction effect was found ($F(2,351) = 3.67$, $p = 0.0264$). Post-hoc analysis showed a statistically significant effect of dynamic versus static faces within the off screen region. More off screen looking was present in the ASD group compared to the controls when static faces were used. However, this group difference was not found using dynamic faces. For the background and face regions, no differences were found (all $p > .05$; cf. Appendix I). The moderators Dynamic_Static in combination with RegionUpperLower and RegionIntExt did not yield any significant interaction effects (cf. Table 3, Appendix B).

Because of limited data points, the interaction parameters for the upright versus inverted faces combined with RegionFaces and RegionIntExt could not be estimated. The same is true for the full versus partial faces and RegionFaces combination. For the other models, estimated effect sizes could be calculated, but this did not yield any significant interaction effects (cf. Table 3, Appendix B).

DISCUSSION

1. Goal of this meta-analysis

This master thesis investigated whether individuals with ASD differed in gaze behavior towards facial stimuli compared to neurotypical individuals. With the use of meta-analytic techniques, the saliency of different facial regions was examined. The results of this meta-analysis were divided into two parts. Firstly, we evaluated whether we could find evidence for differences in viewing behavior in different facial regions. All encountered facial regions were divided in three ways: face (whole face) versus non-face (background and off screen) regions, upper (eyes) versus lower (mouth) face parts and the internal (core facial features: eyes, nose and mouth) versus external facial regions (such as the cheeks, chin and forehead). Secondly, the influence of several moderating variables on these different viewing patterns was examined.

2. Atypical viewing patterns in individuals with ASD

Evidence was found that some facial regions are indeed less or more salient for individuals with ASD compared to neurotypical individuals. A significant difference between the ASD and control group for the face versus non-face regions was found. The results showed that the ASD sample has a clear tendency to direct more social attention towards the non-facial areas, such as the ‘background’ and ‘off screen’ regions. Compared to the control group, facial regions seem to be less salient for the ASD group. Based on these results, it is unclear whether the tendency to look more towards the non-face areas of a stimulus in ASD is a matter of disinterest in facial (or social?) stimuli or a matter of active avoidance of faces (or social situations?).

As many studies and a previous meta-analysis have demonstrated before (e.g. Dalton et al., 2005; Jones & Klin, 2013; Joseph & Tanaka, 2003; Klin, Jones, Schultz, Volkmar & Cohen, 2002; Papagiannopoulou, Chitty, Hermens, Hickie & Lagopoulous, 2014; Riby, Doherty-Sneddon & Bruce, 2009), our meta-analysis clearly showed that the ASD group directs less attention towards the eye region. However, in addition to previous reviews and meta-analyses evaluating this matter (Falck-Ytter & von Hofsten, 2011; Guillon, Hadjikhani, Baduel & Rogé, 2014; Papagiannopoulou et al., 2014), our results also provide further clarity in the debate concerning the saliency of the mouth region. Individuals with ASD showed significantly less attention for *all* internal face regions. The mouth and nose areas, in addition to the eyes, were less salient in those with ASD. This goes against the conclusions of some much-cited and prominent studies which state that individuals with ASD spend significantly more time viewing the mouth (Klin et al., 2002; Langdell, 1979; Joseph & Tanaka, 2003; Neumann, Spezio, Piven & Adolphs, 2006; Tanaka et al., 2012; Wolf et al., 2008).

When individuals with ASD look towards the face, they seem to have a preference for the external facial features. These features, such as the forehead, chin and cheeks, are less informative when processing and interpreting faces (Chelnokova & Laeng, 2011). The tendency to direct less attention towards the informative features of the face can be a plausible explanation as to why these individuals perform slightly worse in a wide range of face-processing tasks (Weigelt, Koldewyn & Kanwisher, 2012); and thus be the source of their selective face impairments. Furthermore, this might relate to why individuals with ASD are impaired in the development of a Theory of Mind (Baron-Cohen, Tagen-Flusberg & Cohen, 1994). More specifically, by focusing on less informational face parts, it is possible that they miss crucial information to extract someone's mental state. Not focusing on, for instance, the mouth and eyes could cause difficulties in recognizing and understanding other individuals' emotions (Uljarevic & Hamilton, 2013; for demonstrations in individuals with ASD, see for example Adolphs, Sears & Piven, 2001; and Grossman, Klin, Carter & Volkmar, 2000), and in manifesting emphatic behavior (Sigman, Kasari, Kwon & Yirmiya, 1992). However, it could also be the case that individuals with ASD lack important Theory of Mind precursors, such as for example joint attention, disabling them to deduce the informative facial regions in the context of reading someone's mind (Baron-Cohen, 1991).

3. Task aspects of social looking behavior

Previous studies (e.g. Joseph and Tanaka, 2003) indicated that spontaneous orientation towards more local aspects of faces in individuals with ASD could be overcome by including specific task instructions. Therefore, we examined whether the encountered atypical gaze patterns were influenced by including certain task demands.

The conclusions described above, i.e. the tendency of participants with ASD to focus more on less informative aspects when being confronted with a face appeared only present in tasks where participants could freely view the faces. However, when explicit task instructions were provided, the differences in gaze behavior disappeared . Our results showed that the explicit task instructions attenuated their preferential bias to look more towards the background, off screen and external facial regions, as these regions were now equally salient for both participant groups. Nevertheless, we did not find any evidence of an increase of the saliency of the internal facial regions for the ASD sample. The core facial features remained inherently less salient for participants with ASD, even when explicit task instructions were provided. It is not clear where they do look at instead, since the saliency of the other facial features remains the same.

Many different sorts of tasks were used to detect differences in saliency of certain facial features between neurotypical individuals and participants with ASD. Further analyses that took into account the nature of the provided task instructions yielded some evidence that this bias towards the non-important regions of a facial stimulus was especially present when participants were explicitly instructed to focus on the local details of faces . When presented with a local instruction, that explicitly asks to direct attention towards specific facial regions (mostly the mouth or eyes, as for example in the studies of Rutherford, Clements, & Sekuler, 2007; and Wallace, Coleman & Bailey, 2008), individuals with ASD direct significantly *less* social attention towards facial regions which were before very salient for them, such as the cheeks, chin or forehead. However, local instructions do not seem to help in directing attention towards the 'more desirable' facial areas such as the eyes or mouth. It seems that individuals with ASD need a larger boost than quite general task instructions to focus on the core facial features. Perhaps they might benefit from feedback during the experiment, or for example explicit training, which as was already suggested by Zürcher et al. (2013).

Moreover, this effect was not found for the background and off screen regions, and thus seems not generalizable towards all sorts of task situations. A plausible explanation however might be that these background and off screen areas are not often included in the recording of gaze patterns, as by tradition the focus of most studies lies in investigating the saliency of upper versus lower facial regions.

4. The (undefined) role of participant characteristics

Overall, our findings on gender, age and intellectual abilities suggested that the most strongly pronounced differences between the ASD and control groups reside in the all-male groups, the ages between 12 and 25 years old and in individuals with an IQ in the normal range. However, it is important to note that some participant categories, such as individuals with an intellectual disability, participants younger than 12 years or older than 25 years as well as females, remain thoroughly outnumbered by the other subgroups in the studies that are included in this meta-analysis. This also limits the conclusions we can draw from our results.

Further research including these specific subgroups seems necessary to investigate the effect of developmental, gender and intellectual characteristics more precisely. For now, it is difficult to define conclusions regarding gender differences, differential developmental trajectories or the impact of intellectual disabilities on the saliency of facial features.

Except for the study of Jones and Klin (2013), which followed infants from 2 to 36 months of age, no longitudinal studies looked into developmental trajectories of patterns of social attention in ASD. Some studies included a broader age range, such as Riby, Doherty-Sneddon and Bruce (2009) and Speer, Cook, McMahon & Clark, 2007, but they found no evidence for a correlation between age and social looking behavior. However, O'Hearn and colleagues (2014) did found that deficits become more robust in adulthood. The reviews of Falck-Ytter and von Hofsten (2011) and Guillon, Hadjikhani, Buduel and Rogé (2014), evaluating the excess mouth/diminished eye gaze hypothesis, found little evidence for this hypothesis and similar gaze patterns in infants, children, adolescents and adults across different studies.

5. Methodological limitations

A first limitation involves the selection and coding of the studies. The results of a meta-analysis depend on the studies included. A problem that can occur during the selection of studies is referred to as 'the file drawer problem'(Rosenthal, 1979). This term refers to a bias in the scientific literature as a result of selective publication because of the tendency of researchers and publishers to publish positive results rather than negative or inconclusive results. As a result, the unpublished non-significant results are imagined to be tucked away in researchers' drawers because they are not published. This can cause a threat to the validity of the results and conclusions because it creates a misrepresentation of the subject under investigation. The funnel plot that resulted out of our visual inspection seems slightly asymmetrical, with more positive effect sizes on the right side of the plot. However, this might be caused by the fact that we looked at the results across all regions. Not all regions are described in every study. For instance, the 'off screen' or 'background' are fairly underrepresented, while these are actually the regions that tend to attract less attention from individuals with ASD. Moreover, when investigating the nature of social gaze behavior in ASD, most researchers choose to include full, static and upright facial stimuli in their paradigms. A consequence of this is that it is not possible to properly investigate the effect of static versus dynamic, upright versus inverted and full versus partial faces on social gaze behavior, as there are too few data points in the dynamic, inverted and partial categories.

The results of a meta-analysis also depend on how studies are coded and on which variables are included. Firstly, the composition of our categories for the included categorical variables might seem arbitrary. Category boundaries are based on pragmatic conventions, such as for example for the IQ measures: we included a group for IQ scores lower than one standard deviation of 15 IQ points below the assumed population mean of IQ 100, a group for IQ scores between 85 and 115 (the 'normal' range), and a group for IQ scores higher than one standard deviation of the assumed mean. However, because IQ scores are assumed to be normally distributed, this leads to a high number of observations in the 'normal range' category, and fewer in the other two categories. A possible method to avoid this could be to divide the observed IQ scores in three groups, such that each group has the same number of observations (e.g. 33% lowest IQ, 33% highest IQ and 33% average IQ). Our approach has the advantage that IQ scores across different studies can be objectively interpreted.

Secondly, to provide clarity in a wide clutter of information, we chose to code a certain selection of all possible variables that studies could include. In the context of this master thesis, only some of these coded variables were analysed. Only variables that had enough observations in each category and models that could improve interpretability were included in the meta-analysis. The possibility remains, therefore, that we have missed some effect, although we think this is unlikely.

Another issue for further consideration is that of ecological validity. This refers to the extent to which the results of this meta-analysis can be generalized to real-life settings. Because most experiments that were used in this meta-analysis recorded gaze behaviors in laboratory settings, with facial stimuli presented in greyscale, as cartoon faces etc., some of the conditions have little resemblance with every-day-, real-life settings. Although this is mainly an issue that is true for the whole field of behavioral research, the question thus remains whether these results have a high applicability in real-world settings.

6. Conclusion

In summary, social attention research and the investigation of gaze behavior in ASD has known an exponential growth since the emergence of eye-tracking technologies. However, contradictory findings in individual studies continue to be the case. Reviews and meta-analyses such as ours play a valuable role in evaluating the large amount of information that is present in the literature and in formulating a clear picture of the gaze patterns in ASD. This meta-analysis convincingly demonstrated atypical gaze patterns in ASD, and has identified several variables that can influence these atypical gaze tendencies. Further research should include the examination of social attention in commonly under-investigated ASD samples, and use a diversity of facial stimuli, to enlarge generalizability.

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APPENDICES

Appendix A

Tests of Fixed Effects and Least Square Means Estimates for Models with One Moderator.

Table 2.

Tests of Fixed Effects and Least Square Means Estimates for Models with One Moderator.

Model		*g*	*SE*	*df*	*t*	*p* > *t*	*F*	*df* num	*df* den	*p* > *F*
Measure	Accuracy	-0.8784	0.2041	20.4	-4.30	.0003	2.08	8	85.5	.0460
	RT	0.4809	0.6218	43.8	0.77	.4434				
	NumFix	-0.3527	0.2465	89	-1.43	.1560				
	PropFix	-0.5770	1.1454	182	-0.50	.6150				
	PropTime	0.1837	0.7509	182	0.24	.8070				
	FixDur	0.0298	0.1318	31.2	0.23	.8224				
	FirstFix	0.1011	0.8288	125	0.12	.9031				
	RawNum	-0.4381	0.7461	154	-0.59	.5579				
	Saccad	-0.4642	0.6043	86.1	-0.77	.4446				
RegionFaces	Face	-0.5246	0.1055	30.7	-4.97	< .0001	99.41	2	345	< .0001
	Background	1.6447	0.2423	195	6.79	< .0001				
	Offscreen	6.7439	0.6352	355	10.62	< .0001				
RegionUpperLower	Upper	-0.7955	0.1385	57.1	-5.74	< .0001	8.11	2	152	.0005
	Lower	-0.3189	0.1473	64.7	-2.16	0.0341				
	Mid	-0.1589	0.2784	160	-0.57	0.5690				
RegionIntExt	Internal	-0.6316	0.1173	40	-5.38	< .0001	39.35	1	211	< .0001
	External	0.8277	0.2381	182	3.48	0.0006				

Note. This analysis is completed using SAS 9.4 University Edition Mixed Procedure (SAS Institute Inc., 2015) and the restricted maximum likelihood procedure. The Satterthwaite approach was used to estimate the degrees of freedom for the statistical significance test. Abbreviations: *g* = estimated Hedges' *g*, *SE* = standard error, num *df* = degrees of freedom in the numerator, den *df* = degrees of freedom in the denominator, *F* = results of an *F*-test, *p* = *p*-value of the test.

Appendix B

Tests of Fixed Effects For All Models with Multiple Moderators

Table 3.

Tests of Fixed Effects For All Models with Multiple Moderators.

Model	Effects	*df* num	*df* den	*F*	*p > F*
RegionFaces, Gender	RegionFaces	2	247	63.83	< .0001
	Gender	2	184	14.79	< .0001
	RegionFaces x Gender	2	247	18.37	< .0001
RegionUpperLower, Gender	RegionUpperLower	2	135	6.28	0.0025
	Gender	2	107	1.83	0.1660
	RegionUpperLower x Gender	3	137	4.03	0.0087
RegionIntExt, Gender	RegionIntExt	1	140	10.54	0.0015
	Gender	2	115	0.41	0.6625
	RegionIntExt x Gender	2	152	5.25	0.0062
RegionFaces, Age (based on ASD)	RegionFaces	2	266	30.96	< .0001
	Age	4	92.5	6.70	< .0001
	RegionFaces x Age	5	249	14.04	< .0001
RegionUpperLower, Age (based on ASD)	RegionUpperLower	2	149	4.26	0.0159
	Age	4	79.8	2.26	0.0697
	RegionUpperLower x Age	7	142	2.43	0.0220
RegionIntExt, Age (based on ASD)	RegionIntExt	1	217	27.83	< .0001
	Age	4	79.4	1.35	0.2574
	RegionIntExt x Age	4	211	6.54	< .0001
RegionFaces, Age(based on TD)	RegionFaces	2	255	26.64	< .0001
	Age	4	144	5.16	0.0006
	RegionFaces x Age	5	236	8.80	< .0001
RegionUpperLower, Age (based on TD)	RegionUpperLower	2	140	5.53	0.0049
	Age	4	106	2.22	0.0716
	RegionUpperLower x Age	8	136	2.67	0.0094
RegionIntExt, Age(based on TD)	RegionIntExt	1	217	29.41	< .0001
	Age	4	103	1.21	0.3097
	RegionIntExt x Age	4	210	6.81	< .0001
RegionFaces, VIQ (based on ASD)	RegionFaces	2	132	6.90	.0014
	VIQ	2	132	3.72	.0268
	RegionFaces x VIQ	2	132	4.14	.018
RegionUpperLower, VIQ (based on ASD)	RegionUpperLower	2	83	5.26	.0071
	VIQ	2	9.61	0.01	.9855
	RegionFaces x VIQ	3	81.8	0.20	.8953
RegionIntExt, VIQ (based on ASD)	RegionIntExt	1	96.2	0.21	.6472
	VIQ	2	10.2	0.65	.5429
	RegionIntExt x VIQ	1	96.2	8.06	.0055
RegionFaces, VIQ (based on TD)	RegionFaces	2	77.6	1.93	.152
	VIQ	1	6.27	0.05	.8282
	RegionFaces x VIQ	.	.	.	.

RegionUpperLower, VIQ (based on TD)	RegionUpperLower	1	61.1	4.71	.0339
	VIQ	1	10.1	0	.9467
	RegionFaces x VIQ	1	61.1	1.25	.2682
RegionIntExt, VIQ (based on TD)	RegionIntExt	1	45	0.08	.7748
	VIQ	1	10.9	0.01	.9342
	RegionIntExt x VIQ	.	.	.	.
RegionFaces, PIQ (based on ASD)	RegionFaces	2	126	4.45	.0136
	PIQ	2	12.7	1.97	.1804
	RegionFaces x PIQ	2	126	4.65	.0112
RegionUpperLower, PIQ (based on ASD)	RegionUpperLower	2	91.2	0.93	.3978
	PIQ	2	6.85	1.93	.217
	RegionUpperLower x PIQ	3	90.5	0.64	.5897
RegionIntExt, PIQ (based on ASD)	RegionIntExt	1	118	4.46	.0369
	PIQ	2	5.38	0.83	.4867
	RegionIntExt x PIQ	1	118	1.78	.1847
RegionFaces, PIQ (based on TD)	RegionFaces	2	117	0.88	.418
	PIQ	2	6.53	0.36	.7116
	RegionFaces x PIQ	.	.	.	.
RegionUpperLower, PIQ (based on TD)	RegionUpperLower	2	67.4	0.41	.6621
	PIQ	2	7.99	0.41	.6794
	RegionUpperLower x PIQ	3	67.5	0.14	.9348
RegionIntExt, PIQ (based on TD)	RegionIntExt	1	80.7	0.38	.539
	PIQ	2	6.67	0.36	.7096
	RegionIntExt x PIQ	1	80.7	0.49	.4864
RegionFaces, Task	RegionFaces	2	328	70.80	< .0001
	Task	1	131	8.98	0.0033
	RegionFaces x Task	1	243	15.69	< .0001
RegionUpperLower, Task	RegionUpperLower	2	148	9.27	0.0002
	Task	1	92.7	0.33	0.5665
	RegionUpperLower x Task	2	148	1.88	0.1563
RegionIntExt, Task	RegionIntExt	1	210	41.39	< .0001
	Task	1	146	3.08	0.0814
	RegionIntExt x Task	1	208	5.96	0.0154
RegionFaces, Instructions	RegionFaces	2	125	3.40	0.0678
	Instructions	1	126	1.20	0.3034
	RegionFaces x Instructions	2	129	0.56	0.4542
RegionUpperLower, Instructions	RegionUpperLower	2	90.8	8.22	0.0005
	Instructions	2	92.9	0.63	0.5345
	RegionUpperLower x Instructions	2	93.3	0.57	0.5677
RegionIntExt, Instructions	RegionIntExt	1	168	1.85	0.1751
	Instructions	2	148	7.20	0.0010
	RegionIntExt x Instructions	2	161	7.88	0.0005
RegionFaces, Dynamic_Static	RegionFaces	2	345	14.31	< .0001
	Dynamic_Static	1	315	6.47	0.0114
	RegionFaces x Dynamic_Static	2	351	3.67	0.0264
RegionUpperLower, Dynamic_ Static	RegionUpperLower	2	232	0.68	0.5093
	Dynamic_Static	1	227	0.08	0.7818
	RegionUpperLower x Dyn_Stat	2	231	0.11	0.8931
RegionIntExt, Dynamic_Static	RegionIntExt	1	275	3.07	0.0810
	Dynamic_Static	1	246	0.12	0.7327

	RegionIntExt x Dynamic_Static	1	281	0.01	0.9197
RegionFaces, Upright_Inverted	RegionFaces	2	352	30.57	< .0001
	Upright_Inverted	1	254	0.84	0.3591
	RegionFaces x Upright_Inverted	.	.	.	.
RegionUpperLower, Upright_ Inverted	RegionUpperLower	2	226	0.01	0.9888
	Upright_Inverted	1	209	1.17	0.2808
	RegionUpperLower x Up_Inv	1	219	1.33	0.2498
RegionIntExt, Upright_Inverted	RegionIntExt	1	266	3.91	0.0489
	Upright_Inverted	1	232	1.39	0.2398
	RegionIntExt x Upright_Inverted	.	.	.	.
RegionFaces, Face_Parts	RegionFaces	2	322	28.71	< .0001
	Face_Parts	1	266	2.61	0.1071
	RegionFaces x Face_Parts	.	.	.	.
RegionUpperLower, Face_Parts	RegionUpperLower	2	223	2.93	0.0554
	Face_Parts	1	194	5.20	0.0237
	RegionUpperLower x Face_Parts	1	217	1.57	0.2122
RegionIntExt, Face_Parts	RegionIntExt	1	270	0.12	0.7269
	Face_Parts	1	256	4.14	0.0430
	RegionIntExt x Face_Parts	1	271	0.72	0.3975

Note. This analysis is completed using SAS 9.4 University Edition Mixed Procedure (SAS Institute Inc., 2015) and the restricted maximum likelihood procedure. The Satterthwaite approach was used to estimate the degrees of freedom for the statistical significance test. Abbreviations: num *df* = degrees of freedom in the numerator, den *df* = degrees of freedom in the denominator, *F* = results of an *F*-test, *p* = *p*-value of the test.

Appendix C

Estimated Effects for Region and Gender

Table 4.

Least Squares Means Estimates for RegionFaces x Gender.

Region Faces	Gender	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Face	All male (> 85% males)	-1.0055	0.2402	64.6	-4.19	< .0001
Face	All female (> 85% females)	.	.	.	.	.
Face	Mixed groups (matched)	-0.4403	0.1321	31.1	-3.33	0.0022
Face	Mixed groups (non-matched)	0.0915	0.3723	160	0.25	0.8063
Background	All male (> 85% males)	2.1095	0.4514	192	4.67	< .0001
Background	All female (> 85% females)	.	.	.	.	.
Background	Mixed groups (matched)	1.7161	0.3245	174	5.29	< .0001
Background	Mixed groups (non-matched)	.	.	.	.	.
Off screen	All male (> 85% males)	8.5536	0.7437	311	11.50	< .0001
Off screen	All female (> 85% females)	.	.	.	.	.
Off screen	Mixed groups (matched)	0.3556	1.2832	206	0.28	0.7820
Off screen	Mixed groups (non-matched)	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

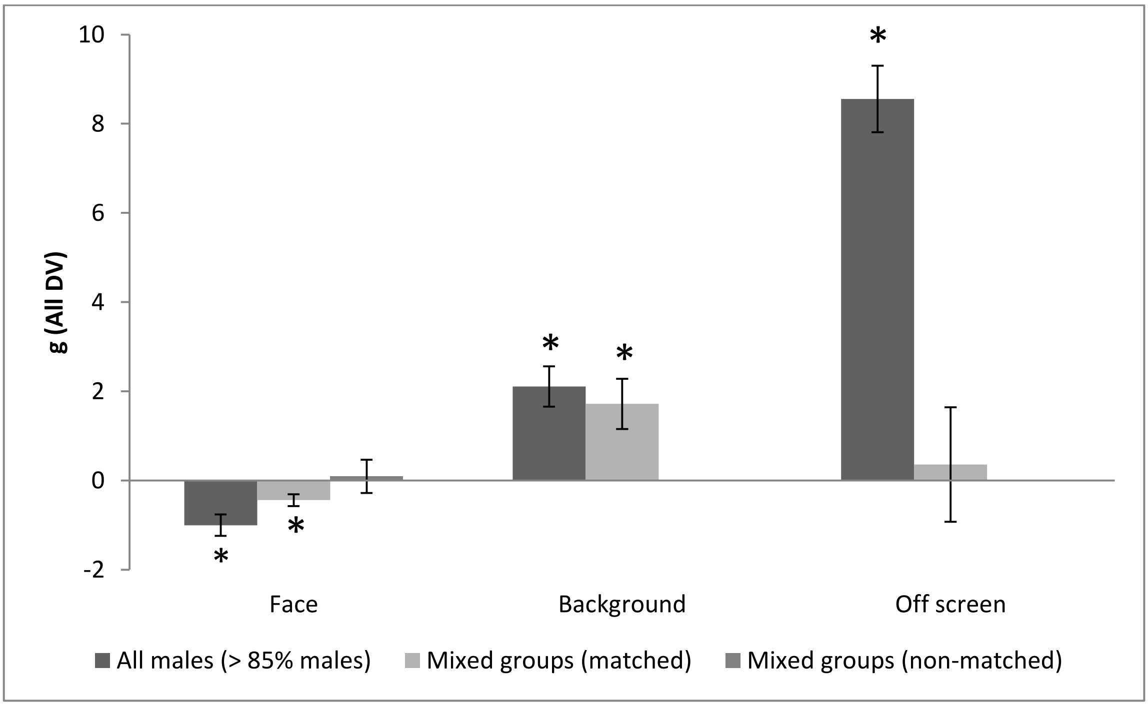

Figure 8. Interaction Effect of RegionFaces and Gender. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Table 5.

Least Squares Means Estimates for RegionUpperLower x Gender.

Region UpperLower	Gender	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Upper	All male (> 85% males)	-1.6280	0.2958	90.3	-5.50	< .0001
Upper	All female (> 85% females)	.	.	.	.	.
Upper	Mixed groups (matched)	-0.6434	0.1757	46.7	-3.66	0.0006
Upper	Mixed groups (non-matched)	-0.4477	0.4289	116	-1.04	0.2987
Lower	All male (> 85% males)	-0.0689	0.3339	101	-0.21	0.8369
Lower	All female (> 85% females)	.	.	.	.	.
Lower	Mixed groups (matched)	-0.3	0.1859	54.5	-1.61	0.1124
Lower	Mixed groups (non-matched)	-0.1474	0.4801	120	-0.31	0.7593
Mid	All male (> 85% males)	-0.7947	0.5145	166	-1.54	0.1243
Mid	All female (> 85% females)	.	.	.	.	.
Mid	Mixed groups (matched)	0.3739	0.4431	132	0.84	0.4003
Mid	Mixed groups (non-matched)	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

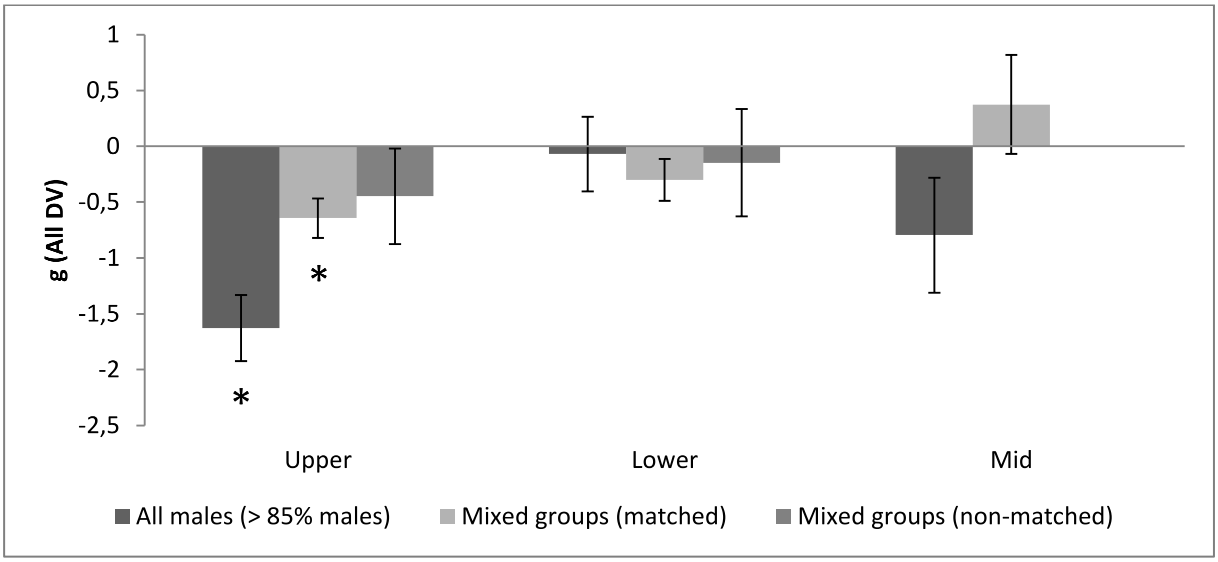

Figure 9. Interaction Effect of RegionUpperLower and Gender. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Table 6.

Least Squares Means Estimates for RegionIntExt x Gender.

Region IntExt	Gender	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Internal	All male (> 85% males)	-1.0603	0.2544	61.6	-4.17	< .0001
Internal	All female (> 85% females)	.	.	.	.	.
Internal	Mixed groups (matched)	-0.4763	0.1576	34.4	-3.02	.0047
Internal	Mixed groups (non-matched)	-0.2160	0.3952	143	-0.55	.5856
External	All male (> 85% males)	1.5921	0.4948	180	3.22	.0015
External	All female (> 85% females)	.	.	.	.	.
External	Mixed groups (matched)	0.3875	0.3229	160	1.20	.2318
External	Mixed groups (non-matched)	0.7397	1.1908	120	0.62	.5357

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

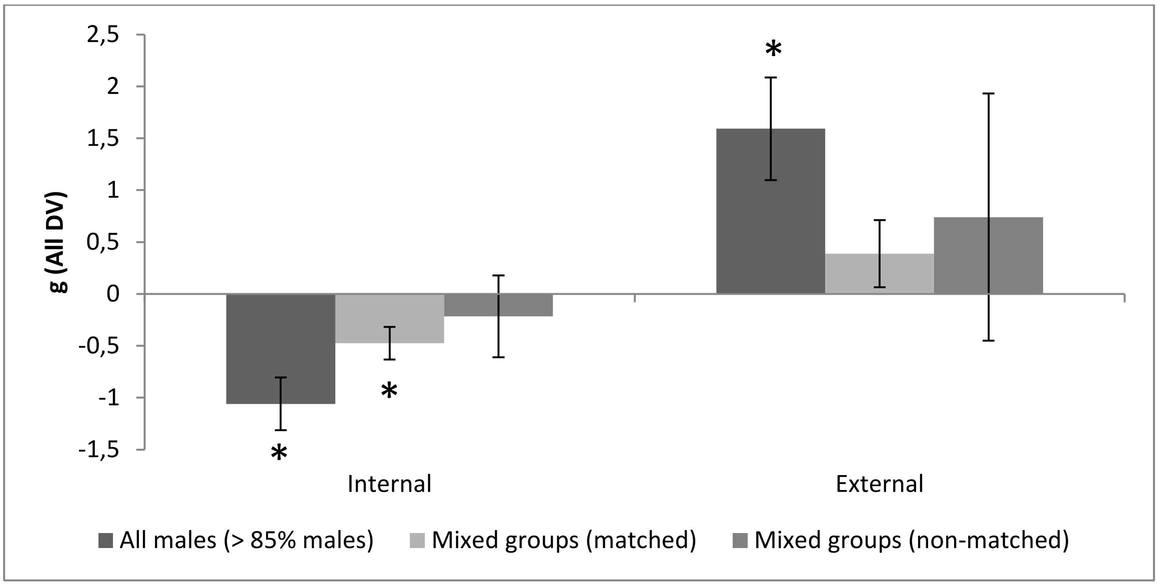

Figure 10. Interaction Effect of RegionIntExt and Gender. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Appendix D

Estimated Effects for Region and Age

Table 7.

Least Squares Means Estimates for RegionFaces x Age.

Region Faces	Age	Estimated *g*	*SE*	*df*	*t*	*p > t*
Face	< 6 years old	0.2192	0.3896	93.7	0.56	.5750
Face	6 – 12 years old	-0.3383	0.2116	28.2	-1.60	.1211
Face	12 – 18 years old	-0.8116	0.2259	42.2	-3.59	.0008
Face	18 – 25 years old	-0.7952	0.2255	22.8	-3.53	.0018
Face	> 25 years old	-0.3774	0.2302	22.1	-1.64	.1153
Background	< 6 years old	0.7018	0.8931	161	0.79	.4331
Background	6 – 12 years old	0.4329	0.4204	155	1.03	.3048
Background	12 – 18 years old	2.8198	0.4045	153	6.97	< .0001
Background	18 – 25 years old	1.7248	0.4344	154	3.97	.0001
Background	> 25 years old	0.5447	1.2831	298	0.42	.6715
Off screen	< 6 years old	0.3202	1.1888	218	0.27	.7879
Off screen	6 – 12 years old	.	.	.	.	.
Off screen	12 – 18 years old	.	.	.	.	.
Off screen	18 – 25 years old	8.6204	0.7104	346	12.14	< .0001
Off screen	> 25 years old	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

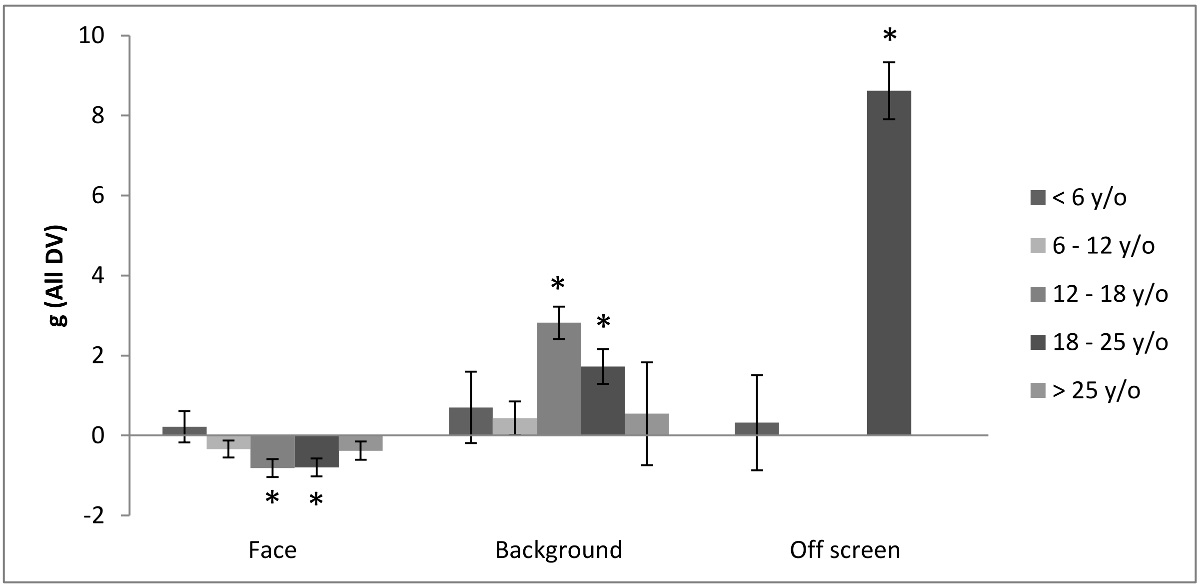

Figure 11. Interaction effect of RegionFaces and Age. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Table 8.

Least Squares Means Estimates for RegionUpperLower x Age.

Region UpperLower	Age	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Upper	< 6 years old	0.1052	0.5422	120	0.19	.8465
Upper	6 – 12 years old	-0.4854	0.2893	42.2	-1.58	.1206
Upper	12 – 18 years old	-0.7012	0.2760	47.6	-2.54	.0144
Upper	18 – 25 years old	-1.7963	0.2903	51.8	-6.19	< .0001
Upper	> 25 years old	-0.5327	0.3097	39.2	-1.72	.0933
Lower	< 6 years old	0.3936	0.5422	120	0.73	.4692
Lower	6 – 12 years old	-0.3250	0.3083	53.5	-1.05	.2966
Lower	12 – 18 years old	-0.3556	0.3218	65.4	-1.11	.2732
Lower	18 – 25 years old	-0.4676	0.2928	52	-1.60	.1163
Lower	> 25 years old	-0.4691	0.3145	39.9	-1.49	.1436
Mid	< 6 years old	.	.	.	.	.
Mid	6 – 12 years old	0.3487	0.7169	141	0.49	.6274
Mid	12 – 18 years old	-0.1663	1.0094	139	-0.16	.8694
Mid	18 – 25 years old	-0.6686	0.3630	85.1	-1.84	.0690
Mid	> 25 years old	-0.0141	1.1711	238	-0.01	.9904

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

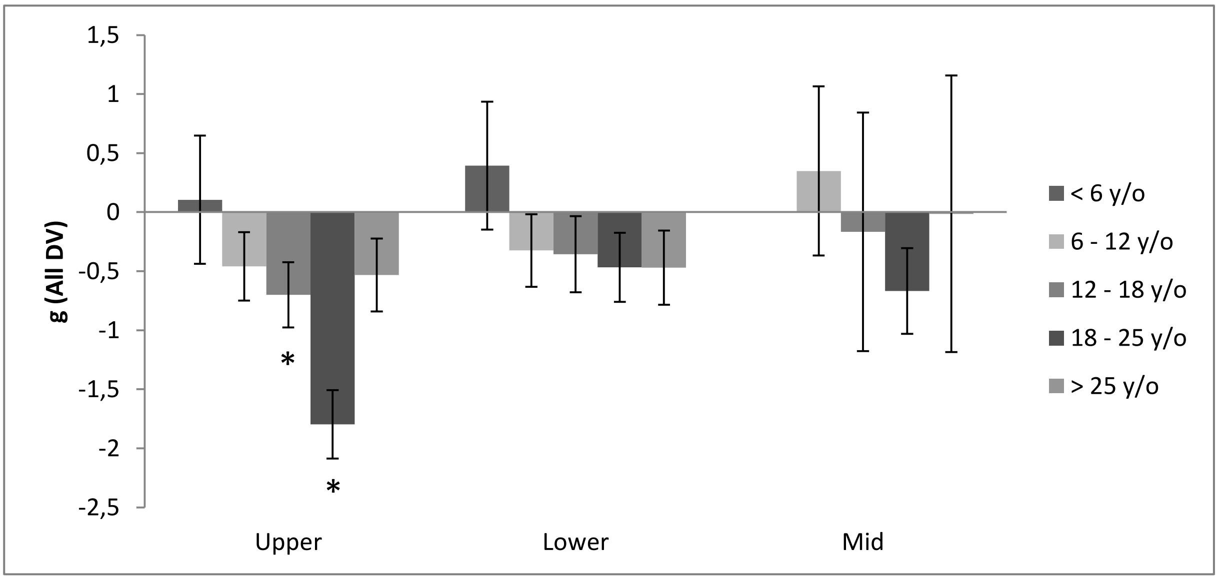

Figure 12. Interaction effect of RegionUpperLower and Age. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Table 9.

Least Squares Means Estimates for RegionIntExt x Age.

Region IntExt	Age	Estimated *g*	*SE*	*df*	*t*	*p > t*
Internal	< 6 years old	0.2016	0.4074	90.7	0.49	.6219
Internal	6 – 12 years old	-0.4300	0.2535	37.4	-1.70	.0981
Internal	12 – 18 years old	-0.7661	0.2692	39.1	-2.85	.007
Internal	18 – 25 years old	-1.0854	0.2570	36.2	-4.22	.0002
Internal	> 25 years old	-0.4854	0.2761	29.1	-1.76	.0893
External	< 6 years old	1.3962	0.7809	193	1.79	.0754
External	6 – 12 years old	0.2724	0.5017	158	0.54	.5879
External	12 – 18 years old	1.5013	0.8392	189	1.79	.0752
External	18 – 25 years old	1.7755	0.4372	150	4.06	< .0001
External	> 25 years old	-0.2092	0.4433	116	-0.47	.6379

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

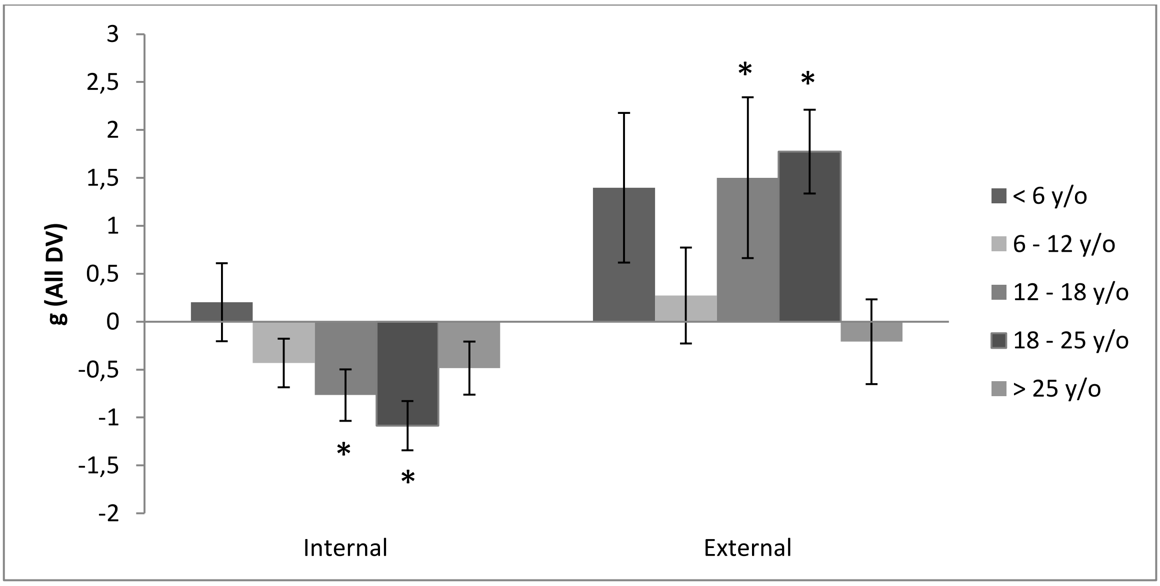

Figure 13. Interaction effect of RegionIntExt and Age. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Appendix E

Estimated Effects for Region and VIQ

Table 10.

Least Squares Means Estimates for RegionFaces x VIQ.

Region Faces	VIQ	Estimated g	*SE*	*df*	*t*	*p > t*
Face	< VIQ 85	-0.4968	0.5001	130	-0.99	.3224
Face	VIQ 85 – VIQ 115	-0.7844	0.362	132	-2.17	.032
Face	> VIQ 115	-0.297	0.5289	132	-0.56	.5745
Background	< VIQ 85	0.5667	1.9198	129	0.29	.7695
Background	VIQ 85 – VIQ 115	2.805	0.71	132	3.95	.0001
Background	> VIQ 115	.	.	.	.	.
Off screen	< VIQ 85	0.1851	2.7292	129	0.07	.946
Off screen	VIQ 85 – VIQ 115	8.1052	1.2156	132	6.67	< .0001
Off screen	> VIQ 115	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

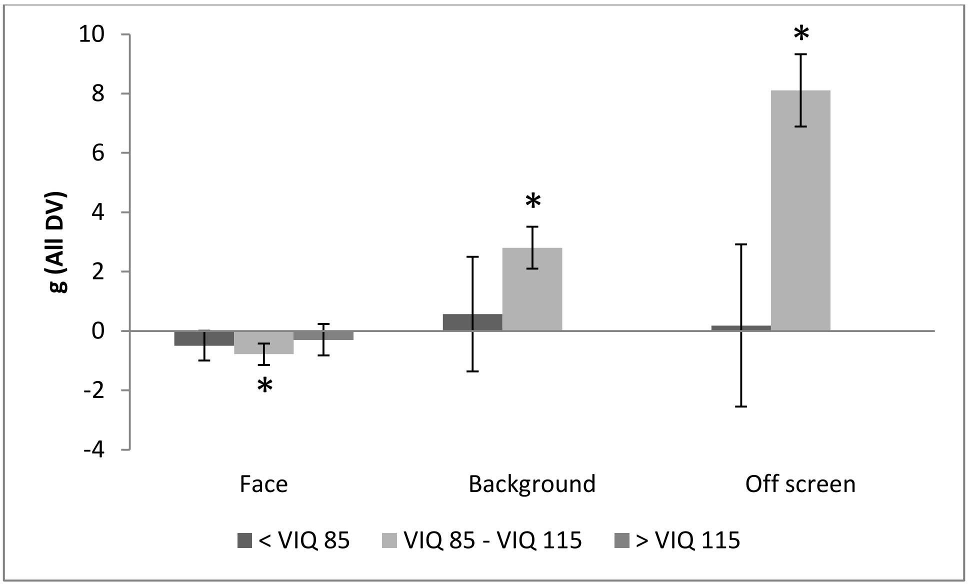

Figure 14. Interaction effect of RegionFaces and VIQ. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Table 11.

Least Squares Means Estimates for RegionIntExt x VIQ.

Region IntExt	Age	Estimated *g*	*SE*	*df*	*t*	*p > t*
Internal	< VIQ 85	0.5823	0.7496	10.6	0.78	.4542
Internal	VIQ 85 – VIQ 115	-0.5677	0.4580	10.7	-1.24	.2416
Internal	> VIQ 115	-0.4042	0.896	6.92	-0.45	.6657
External	< VIQ 85	-1.1966	1.2691	57.8	-0.94	.3497
External	VIQ 85 – VIQ 115	1.8976	0.7540	52	2.52	.015
External	> VIQ 115	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

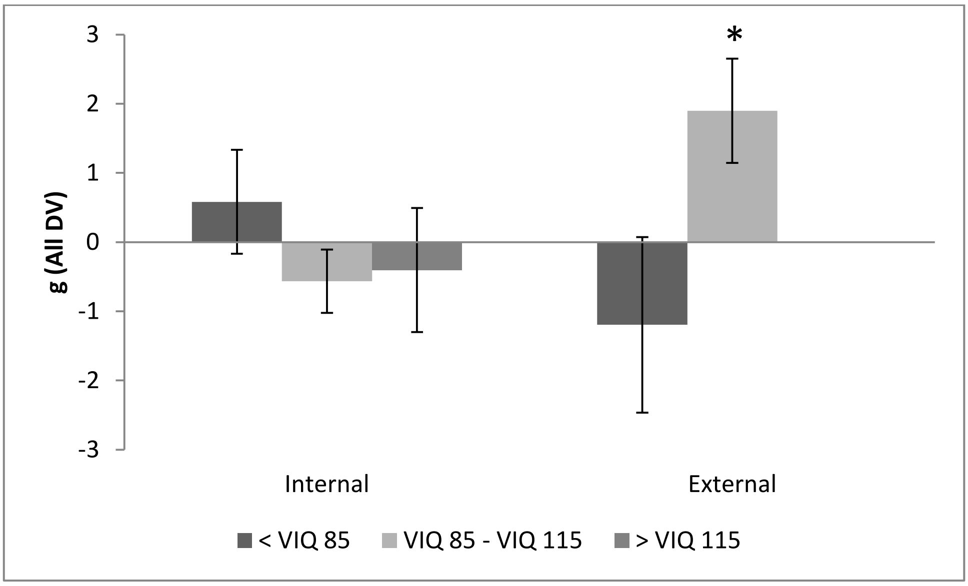

Figure 15. Interaction effect of RegionIntExt and VIQ. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Appendix F
Estimated Effects for Region and PIQ

Table 12.

Least Squares Means Estimates for RegionFaces x PIQ.

Region Faces	PIQ	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Face	< PIQ 85	0.4144	0.5172	12.2	0.80	.4382
Face	PIQ 85 – PIQ 115	-1.1543	0.4031	14.6	-2.86	.0121
Face	> PIQ 115	0.1711	0.5922	6.59	0.29	.7816
Background	< PIQ 85	0.5831	2.038	126	0.29	.7752
Background	PIQ 85 – PIQ 115	1.6981	0.6491	59.7	2.62	.0112
Background	> PIQ 115	.	.	.	.	.
Off screen	< PIQ 85	0.2016	2.8544	150	0.07	.9438
Off screen	PIQ 85 – PIQ 115	7.8125	1.2999	110	6.01	< .0001
Off screen	> PIQ 115	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

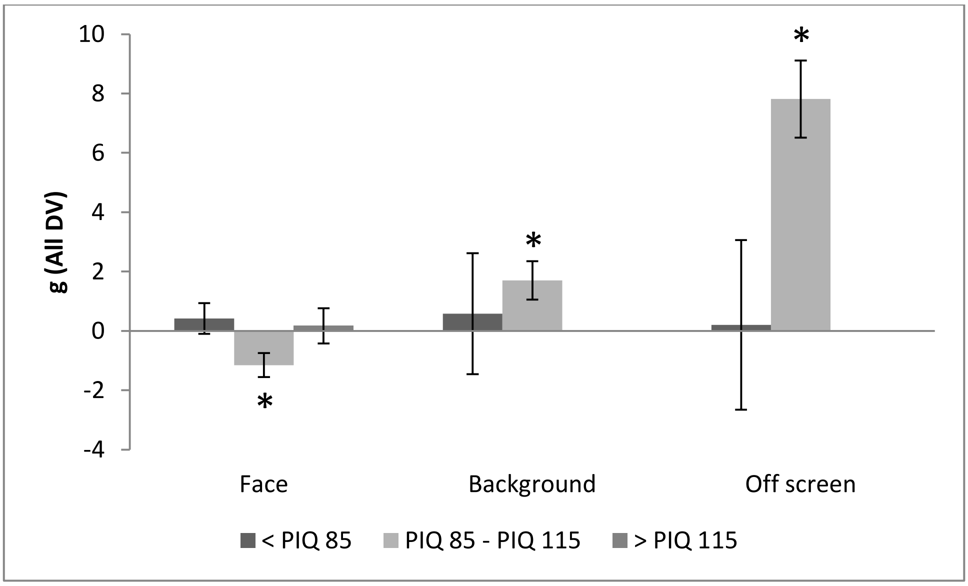

Figure 16. Interaction effect of RegionFaces and PIQ. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Appendix G

Estimated Effects for Region and Task

Table 13.

Least Squares Means Estimates for RegionFaces x Task.

Region Faces	Task	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Face	Instructions	-0.6198	0.1669	50.2	-3.71	.0005
Face	Free viewing	-0.4938	0.14	31.6	-3.53	.0013
Background	Instructions	2.1556	0.2849	163	7.57	< .0001
Background	Free viewing	0.1677	0.46	230	0.36	.7157
Off screen	Instructions	6.771	0.6323	353	10.71	< .0001
Off screen	Free viewing	.	.	.	.	.

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

Table 14.

Least Squares Means Estimates for RegionUpperLower x Task.

Region UpperLower	Task	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Upper	Instructions	-0.8427	0.2093	85.7	-4.03	.0001
Upper	Free viewing	-0.7748	0.1721	56.6	-4.50	< .0001
Lower	Instructions	-0.1412	0.2306	93	-0.61	.5419
Lower	Free viewing	-0.4212	0.1805	64.8	-2.33	.0227
Mid	Instructions	-0.4077	0.3682	161	-1.11	.2698
Mid	Free viewing	0.2842	0.4271	144	0.67	.5068

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

Table 15.

Least Squares Means Estimates for RegionIntExt x Task.

Region IntExt	Task	Estimated *g*	*SE*	*df*	*t*	*p* > *t*
Internal	Instructions	-0.6803	0.1771	62.4	-3.84	.0003
Internal	Free viewing	-0.5947	0.1471	43.1	-4.04	.0002
External	Instructions	1.3613	0.3342	204	4.07	< .0001
External	Free viewing	0.3389	0.316	188	1.07	.2849

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

Appendix H

Estimated Effects for Region and Task_Instructions

Table 16.

Least Squares Means Estimates for RegionIntExt x Task_Instructions.

Region IntExt	Task_Instructions	Estimated *g*	*SE*	*df*	*t*	*p > t*
Internal	Global task	-0.61	0.2019	31.6	-3.02	.005
Internal	Local task	-0.6271	0.2213	38.6	-2.83	.0073
Internal	Global task using local info	-0.4197	0.2116	36.9	-1.98	.0547
External	Global task	0.6953	0.326	105	2.13	.0353
External	Local task	-1.8909	0.6067	150	-3.12	.0022
External	Global task using local info	0.8699	0.7101	159	1.22	.2224

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

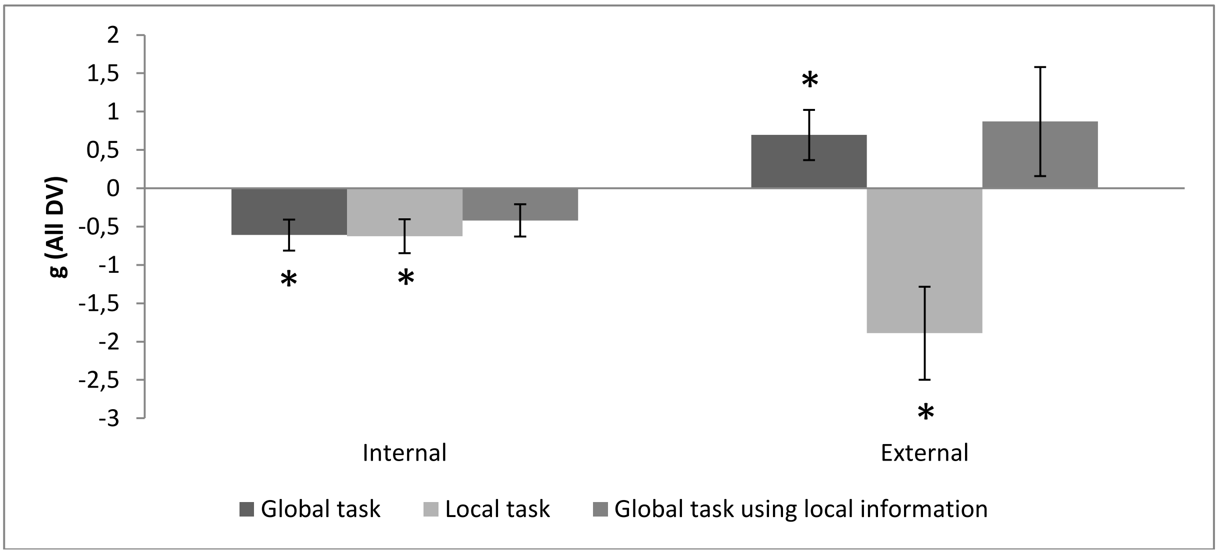

Figure 17. Interaction effect of RegionIntExt and Task_Instructions. Error bars represent the standard errors on the mean, * indicates $p < .05$.

Appendix I

Estimated Effects for Region and Dynamic_Static

Table 17.

Least Squares Means Estimates for RegionFaces x Dynamic_Static.

Region Faces	Dynamic_Static	Estimated *g*	*SE*	*df*	*t*	*p > t*
Face	Static	-0.2408	0.1756	35.6	-1.37	.1788
Face	Dynamic	-0.3125	0.4269	225	-0.73	.4649
Background	Static	2.0119	0.5768	234	3.49	.0006
Background	Dynamic	2.1296	0.7204	310	2.96	.0034
Off screen	Static	8.0976	1.2002	352	6.75	< .0001
Off screen	Dynamic	0.2271	2.6151	336	0.09	.9309

Note. *SE* = standard error, *df* = degrees of freedom, *t* = results of an *t*-test, *p* = *p*-value of the test.

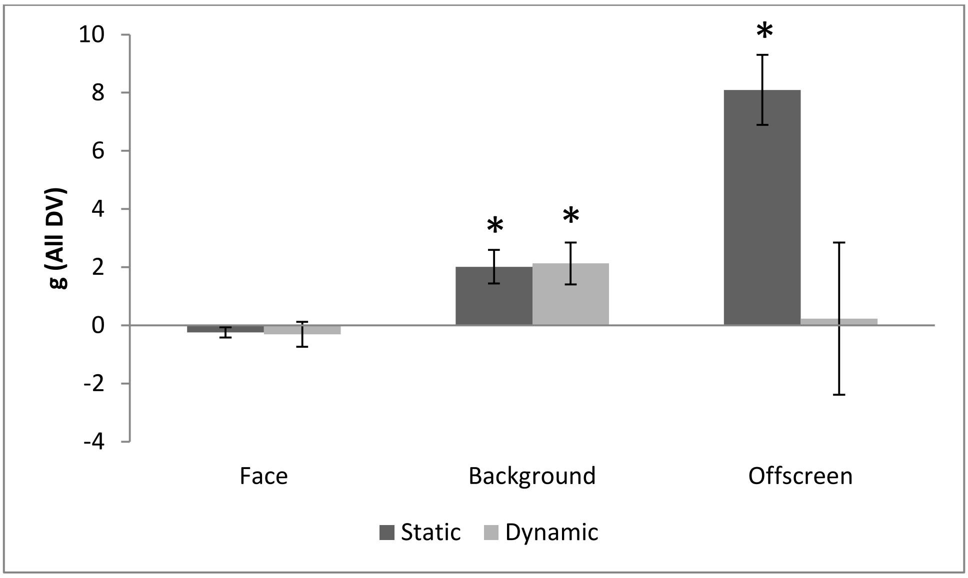

Figure 18. Interaction effect of RegionFaces and Dynamic_Static. Error bars represent the standard errors on the mean, * indicates *p* < .05.