

Congruency Sequence Effects in Pediatric Obsessive Compulsive Disorder

by

Jessica A. Harper

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Advisors:

Dr. Kate Fitzgerald

Dr. Daniel Weissman

Abstract

Obsessive compulsive disorder (OCD) is one of the most prevalent psychiatric conditions, often emerging during childhood and adolescence. Impairments in cognitive processes, including cognitive control, are often found to be critical factors in OCD. Cognitive control in OCD still needs to be further explored. One reflection of impaired cognitive control may be reduced post-conflict adaptation. We tested the hypothesis that children and adolescents with OCD would show impaired post-conflict adaptation demonstrated by congruency sequence effects when compared to healthy controls. Sixteen participants with pediatric OCD and 15 healthy controls between the ages of 11 and 19 filled out clinical measures and performed a faces Stroop task. Differences in reaction time and accuracy were examined by age, group membership, and symptomology. While no significant congruency sequence effects or differences in congruency sequence effects were found between groups, trends towards congruency sequence effects were positively correlated with age in healthy controls but not in OCD participants, suggesting altered developmental trajectories. We also suggest that post-conflict adaptation may be underdeveloped in youth as measured by congruency sequence effects. These findings support the existence of differences in cognitive control, while positing that the cognitive control changes throughout healthy development but fails to do so in OCD development.

Keywords: obsessive compulsive disorder, post-conflict adaptation, pediatric OCD, congruency sequence effects, Stroop task

Congruency Sequence Effects in Pediatric Obsessive Compulsive Disorder

Obsessive compulsive disorder (OCD) affects 1-4% of the general population, making it the fourth most prevalent psychiatric condition (Farrell, Waters, Milliner, & Ollendick, 2012; Aouizerate et al., 2004). Moreover, studies of children and adolescents have indicated that OCD affects 1% to 2.3% of that population (APA, 2000) and that up to 80% of cases emerge during that time period (Rasmussen & Eisen, 1990 as cited in Viard et al., 2005). Symptoms include unwanted, intrusive thoughts or worries and compulsions to carry out rituals (American Psychological Association [APA], 2000). Symptoms are often experienced as unpleasant and intrusive and can interrupt the typical developmental trajectory by causing impairment in schoolwork and school activities, daily routines, family relationships, and social relationships (Farrell et al, 2012), with possible lifelong implications if left untreated.

Disruptions of cognition appear to play a prominent role in the etiology and maintenance of OCD (Barret & Healy, 2003). These include cognitive rigidity, hesitation, and indecisiveness observed clinically (Sachdev & Malhi, 2005 as cited in Koçak, Nalçacı, Özgüven, Nalçacı, & Ergenç, 2009) and impaired performance on experimental tasks designed to measure capacity for mental shifting, cognitive inhibition, attentional inhibition, cognitive flexibility, and selective attention (Penadé et al., 2007). These deficits fall under a larger umbrella of deficits in cognitive control, defined as the ability to “control behavior, monitor the consequences of one’s actions, and make behavioral adjustments when necessary” (Norman & Shallice, 1986 as cited in Liu et al., 2012). Children with OCD have subjectively reported having less cognitive control in comparison to healthy controls (Barret & Healy, 2003). One manifestation of this is patient difficulty in controlling or suppressing obsessive thoughts despite their realization that the

obsessions and compulsions are not rational (American Psychological Association [APA], 2000; Meiran, Diamond, Toder, & Nemets, 2011; Penadé et al., 2007).

Cognitive control requires one to detect conflict between competing response options as well as adapt behaviors when facing varying degrees of conflict. High conflict occurs when response options are in contrast with each other (an incongruent trial or situation); low conflict occurs when response options are similar or complement each other (a congruent trial or situation). In tasks requiring cognitive control, one must attend to relevant information while ignoring and avoiding distraction from the irrelevant or conflicting information or stimuli competing for access to cognitive response systems (van Veen & Carter, 2006) – a process known as conflict resolution. One way to resolve such conflict is known as conflict adaptation, slowing responses after one has detected conflict to prepare for conflict that may occur on subsequent trials. This adaptation can be observed through trial-to-trial changes over a run of consecutive incongruent or congruent trials compared to alternation between such trial types. For instance, faster responses are typically noted on incongruent trials that are preceded by other incongruent trials (iI) as opposed to those that are preceded by congruent trials (cI) (Egner, 2007). This phenomenon, known as congruency sequence effects, has been interpreted as indicating adjustments in cognitive control following conflict. Reaction times tend to be faster for incongruent-incongruent (iI) trials than congruent-incongruent (cI) trials resulting from decreased conflict interference, with slower reaction times for incongruent-congruent (iC) trials than for congruent-congruent (cC) trials resulting from reduced facilitation. This is also thought to suggest greater focusing on relevant information after correctly performed incongruent (high conflict) trials than after correctly-performed congruent (low conflict) trials (Liu et al., 2012), but other interpretations are possible (Schmidt, 2013).

One task that generates stimulus conflict is a Stroop task where a conflict occurs between reading a word that says a color (e.g., blue) and the desired response of naming the different color that the word is printed in (e.g., yellow). In Stroop tasks, stimulus conflict is thought to occur because text reading is more automatic than content generation (such as color naming), causing competition between the assigned task (naming the color) and the more automatic task (reading the text) response options during incongruent trials (van Veen & Carter, 2006).

The aforementioned congruency sequence effects could result from the effects of stimulus priming and feature integration in tasks where stimuli are repeated as in the traditional Stroop task (Egner, 2007). Priming occurs when a previously viewed stimulus facilitates processing of and responses to similar subsequent stimuli, influencing responses to those stimuli. Feature integration theory posits that viewers process stimuli first by their features and only slightly later as wholes; subsequent repeated features stimulate the stored wholes in memory and result in faster responses (Hommel, Proctor, & Vu, 2004; Treisman & Gelade, 1980). So, if a similar stimulus were presented in the ensuing trial in the traditional Stroop task, a faster response might indicate effects of priming or feature integration rather than the effects of congruency, calling for a task where priming and feature integration are minimized (Egner, 2007). A faces Stroop task minimizes these confounds and allows for better isolation of congruency effects by not repeating exact stimuli in consecutive trials. In such a task, identifying text, the more automatic process, competes with gender or emotion identification performed on the face.

Healthy individuals experience intrusive thoughts and behaviors, but are able to adapt future thoughts and behaviors with the realization that such thoughts and behaviors are not appropriate (conflict detection) (Rachman & de Silva, 1978). In contrast, an OCD patient may

get “stuck” in a compulsion, because he or she fails to appropriately resolve conflict between rational and obsessive thoughts. Because OCD patients often do recognize their thoughts and behavioral as situationally inappropriate (APA, 2000), it is unlikely that this failure is a result of an impaired ability to detect conflict. Rather, it may be that OCD patients fail to recruit cognitive control, hindering their ability to inhibit thoughts and behaviors or switch to more appropriate thoughts and behaviors in spite of their insight and discomfort (Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005). This may be exemplified in reduced post-conflict adaptation as measured by congruency sequence effects if clinical and experimental manifestations do indeed utilize similar processes and therefore elicit similar deficits.

Because a large percentage of OCD cases emerge during childhood and adolescence and cause disruption in school and social activities, it makes sense to examine cognitive control as a possible contributing factor in that age group. Developmentally normative obsessive-compulsive behaviors also diminish around this time (Evans, Lewis, & Iobst, 2004), making looking for group differences cleaner. Healthy children and children with OCD often differ in their presentation of congruency sequence effects. Patients in a study by Meiran and colleagues (2011) showed reversed post-conflict adaptation while healthy children showed no effect. This suggests possible deficits in cognitive control and failures to recruit the control processes necessary to adapt (Liu et al., 2012). Additionally, these differences suggest that certain aspects of cognitive control are not fully developed in youth and even lesser developed in youth with OCD. In fact, subjective questionnaires have found that OCD symptoms are negatively associated with one’s perceived ability to control thoughts (Grisham & Williams, 2009). Other studies have shown that OCD patient responses are slower regardless of trial type, suggesting that they may experience a general cognitive slowing separate from the order in which they experience conflicting stimuli

(Koçak et al., 2009; Viard et al., 2005). Examining deficits in processing conflicting stimuli may be an integral part in examining the phenomenology of obsessive–compulsive symptoms (Viard et al., 2005). Additional data suggests that these deficits may change over that developmental track of OCD patients and that this developmental track may differ from that of healthy children on a structural level (Huyser, Veltman, Wolters, de Haan, & Boer, 2007). This suggests the importance of examining task response differences using both age and psychopathology as factors should a similar developmental discrepancy exist on a cognitive-behavioral level.

Based on indications that deficits in cognitive control contribute to clinical presentations in OCD participants getting “stuck” in the research presented above, the present study sought to explore behavioral manifestations of cognitive control processing in youth with OCD in an experimental task. We predicted that children and adolescents with OCD would show reduced congruency sequence effects through reduced post-conflict adaptation (iI trials faster than cI trials) exhibited by slower iI trials or iI trials that are not significantly faster, as well as a failure to exhibit increased post-conflict adaptation with age when compared with healthy children and adolescents.

Method

Participants

Thirty-one children and adolescents aged 11-19 ($M = 14.55$, $SD = 2.26$) participated in this study. Sixteen patients with pediatric OCD (9 male, 7 female) and 15 healthy controls (8 male, 7 female) were recruited from October 2012 to March 2013 from the community and the Child and Adolescent Psychiatry Department of the University of Michigan Health System as part of a larger neuroimaging study of pediatric OCD. Participants were not matched for gender or age due to recruitment and clinical resource constraints, however, the differences in gender

ratio and mean age between groups were not significant. OCD subjects had a primary diagnosis of OCD, assessed by a structured clinical interview using the KSADS and SOCOBs administered by a masters level clinician with extensive experience with pediatric OCD and anxiety. OCD participants with pervasive developmental disorders or ADHD were excluded; participants with comorbid anxiety, depression, and tic diagnoses were included. OCD participants varied in treatment status with four receiving cognitive behavioral therapy (CBT) ($n = 5$), five taking medication ($n = 5$), three receiving CBT and taking medication ($n = 3$), one not currently taking medication after having taken it in the past ($n = 1$), and two being treatment naïve ($n = 2$). Healthy controls had no history of psychiatric problems or first-degree relatives with psychiatric problems. After reviewing the information about the study, we obtained written consent from participants and their parents or guardians; we also obtained written assent for participants under fourteen years of age.

Subject characterization

Clinical measurements: *K-SADS*. The Kiddie–Schedule for Affective Disorders is a semi-structured interview tool used to assess diagnostic criteria and symptomology for several disorders, including OCD (Kaufman et al. 1997). A study by Lauth and colleagues (2005) found that using the K-SADS with adolescents in clinical settings increased the rates of patients diagnosed with a number of disorders, suggesting that the using the K-SADS may decrease underreporting problems that present in non-structured interview settings. A clinician using the K–SADS semi-structured interview performed diagnostic screening on all participants to assess both the fits of OCD diagnoses and the absence of current or prior psychopathology in healthy controls. These assessments were performed at the time of enrollment in the larger study an average of 7.8 months from enrollment in the current study. Self-report instruments were used

to assess the presence of active OCD diagnosis and severity of OCD and other symptoms (e.g., general anxiety, depression) for the current study.

OCI-R. The Obsessive Compulsive Inventory-Revised is an eighteen-question measure that asks participants to rate how much symptoms have bothered them during the past month on a Likert-type scale from 0 (not at all) to 4 (extremely). The inventory breaks into six empirically derived subscales (hoarding, washing, checking, ordering, obsessing, and neutralizing) and has high internal consistency, test-retest reliability, convergent validity, and divergent validity (Foa et al., 2002; Hajcak, Huppert, Simons, & Foa, 2004). OCI-R self-report scores are also correlated with scores on observer ratings of OCD symptom severity, all of which are consistently higher in OCD patients than in controls (Foa et al., 2002). It is, however, still usable in nonpatient samples to characterize sub-clinical OCD symptomology (Hajcak et al., 2004). The OCI-R was used to evaluate the severity of OCD symptoms during the past month for both OCD participants and healthy controls. Although the OCI-R assesses compulsions more than obsessions (Foa et al., 2002), its ability to distinguish OCD symptoms as distinct from depression and worry (Hajcak et al., 2004) and its utility across clinical and research purposes (Huppert et al., 2007) made it a suitable match as a primary measure for this study.

MASC. We used the Multidimensional Anxiety Scale for Children to measure a wider range of anxiety disorder symptomology than is measured with the OCI-R since pediatric patients with OCD often present with other forms of anxiety in addition to OCD (Geller et al, 1998). The thirty-nine-item questionnaire assesses anxiety symptomology across four scales (physical symptoms, harm avoidance, social anxiety, and separation/panic) using a Likert-type scale ranging from 0 (never true about me) to 3 (often true about me) (March, Parker, Sullivan, Stallings, & Conners, 1997). Studies have shown that the MASC has good divergent validity,

discriminates well between anxiety and depression (Rynn et al., 2006) and that it maintains similar reliability and concurrent validity across inpatient, outpatient, and nonclinical youth samples (Osman et al., 2009). Results from Osman et al. (2009) suggest that the MASC may not help differentiate anxiety in patients with less severe anxiety, making it a better support measure than primary measure in the present study.

CDI. The Child Depression Inventory is a twenty-seven-item self-report questionnaire that asks participants to choose the statement that most applies to their feelings during the previous two weeks from a set of three (eg. “I am sad once in a while”, “I am sad many times”, “I am sad all the time”). These responses are then coded from 0 to 2 and totaled, with higher scores correlated with depressive symptoms (Kovacs, 1992). Raw responses are then converted into t-scores based on age and gender. This assessment was used in the present study primarily to ensure that any findings could not be better accounted for by comorbid depressive rather than obsessive-compulsive symptoms. Both OCD patients and healthy controls completed the CDI, along with the MASC and OCI-R on the day that they completed the behavioral task (with the exception of four participants who completed the CDI and MASC within two weeks of the task).

CBCL. The Child Behavior Checklist parent-report questionnaire was used to rate child and adolescent subjects on a range of emotional and behavioral difficulties during the past six months using 118 questions on a Likert-type scale from 0 (not true) to 2 (very true or often true) (Achenbach, 1991). It can be broken down into subscales including affective problems, somatic problems, obsessive-compulsive problems, and anxiety problems to reflect the comorbidities that are often present in pediatric OCD (Storch et al., 2006). The CBCL was used in the present study mainly to corroborate the MASC and OCI-R. Parents completed the CBCL on the day of the task only if they had not done so within the past six months.

Behavioral Task and Data Collection. Subjects sat approximately 44 centimeters from a computer in a quiet room where they performed a face-word Stroop task with stimuli provided by Egner (2010) via Carp and Weissman (2012) on Presentation software. Before beginning the experiment, participants practiced the task with a run of 24 trials with auditory feedback (beeps) after incorrect responses. Eight 96-trial runs of the task adapted from recent studies by Carp and Weissman (2012) and Egner and colleagues (2010) followed the practice run. Once participants were able to complete the practice run at or above the 80% accuracy threshold, the experimental runs would begin. The computer presented participants with either red “female” text or red “male” text superimposed on a black and white image of either a male or female face for 1000 ms (see Figure 1).

Participants were instructed to identify the gender of the face in the image while ignoring the superimposed word as quickly and as accurately as possible. In congruent trials, the genders of the facial image and the word were the same (e.g., “female” on a female face); in incongruent trials, the genders of the facial image and the word conflicted (e.g. “female” on a male face). Participants were given a 1000 ms window to identify the gender of the face by pressing one of two corresponding keys on the computer keyboard. This was followed by a 2000 ms interstimulus interval before the next trial. Exact stimuli repetitions were prevented by alternating the case of the text every trial and not repeating any face across consecutive trials.

Data Analysis

Data were extracted from the Presentation software log files using an R script that created subsets of the data based on whether trials were congruent or incongruent and then further analyzed that data by reaction time and accuracy. Prior to analyzing the data, we removed trials in which no response was made. When analyzing reaction time, we also removed trials answered

incorrectly as well as the trials immediately after these errors; these trials were, however, still included in analyses of task accuracy. One participant with extremely low accuracy (25%) that fell below the 80% accuracy threshold and one participant identified as an outlier (with reaction times greater than 2.5 standard deviations from the mean) were also removed prior to analysis, leaving 29 total participants (14 OCD, 15 HC). Analyses for this study were performed using IBM SPSS statistics. We performed t-tests to evaluate congruency sequence effects in reaction time and accuracy across and within groups. We also investigated relationships between iI-cI reaction time differences and OCD severity measured by the OCI-R using a Pearson's correlation. Additionally, we used a Pearson's correlation to investigate the relationships between age and iI-cI reaction time differences.

Results

Inconsistent with our hypotheses that OCD patients would should reduced congruency sequence effects, independent samples t-tests showed no statistically significant mean differences in congruency sequence effects between groups; the same was true for iI-cI and cC-iC accuracy rates between groups. Further, two-tailed one sample t-tests did not reveal statistically significant congruency sequence effects within groups for iI-cI trials or cC-iC trials. Considering the possibility that reaction time differences may be better correlated with the spectrum in symptomology than discrete group differences, we also performed a correlation analysis for iI-cI reaction times and the clinical measures (OCI-R, MASC, CDI, and CBLC); this also did not reveal statistically significant results, $p > .1$. There were also no significant conflict effects, or differences in accuracy and reaction time on incongruent versus congruent trials, between or within groups.

Age and iI-cI reaction time showed a significant negative trend for healthy controls, $r = -.514$, $p = .050$, but not for OCD participants, $r = -.007$, $p = .98$, providing support for our hypothesis that OCD patients would show a developmental difference in post-conflict adaptation. There was no statistically significant age correlation with iI-cI accuracy in either group. Higher OCI-R scores did not correlate with accuracy or reaction time in total or in specific trial types, indicating that severity of symptomology may not have an effect on post-conflict adaptation or vice versa.

Discussion

We investigated whether heightened conflict in a trial would result in increases in attention and facilitate faster reaction times in the trial immediately following it as shown by Yanni et al. (2012) but without the confound of priming. The most compelling finding from this study was that healthy controls showed a trend between age and iI-cI trial reaction time changes while OCD participants did not. Healthy controls exhibited increasingly negative differences in their reaction times (faster reactions times on iI trials than on cI trials) as they got older, implying that the underlying cognitive processes became more developed with age. The absence of such a significant trend in OCD participants regardless of symptom severity is consistent with findings that the disorder disrupts the typical developmental trajectory, implying that this disruption may go deeper than daily task and relationship difficulties. Alternatively or additionally, failure to follow this developmental trajectory independent of symptom severity may provide further evidence for cognitive difficulties as critical and innate components of the disorder (supplemented by emotional components). Differences in developmental trajectory also provide support for the need for early intervention in OCD. Whether interventions have the power to change the trajectory could be investigated with a pre- post-treatment study of a similar task.

While our study found that differences in accuracy and reaction time overall between OCD patients and healthy controls were not significant overall, it is worth noting that OCD patients were had insignificantly lower mean reaction times than healthy controls this study. This is inconsistent with earlier findings that OCD patients were significantly slower across trial types by Koçak et al. (2009). One possible reason for this might be that OCD participants cared more about the task and therefore put more effort into recruiting attention, consistent with OCD symptoms of wanting to be correct. This study utilized a small sample size, and it is possible that given a larger sample size we would see larger or different effects in performing analyses.

Finally, the absence of significant congruency sequence effects is inconsistent with findings by Carp and Weissman (2012) that show significant post-conflict adaptation in the same task. As that study was done with adult participants rather than youth, this suggests that these facets of cognitive control are not yet fully developed in youth. Our finding that this effect increases with age in healthy controls would support this. Longitudinal studies of pediatric OCD into adulthood are needed to further explore this. If post-conflict adaptation fully develops later in life, it would suggest that impaired post-conflict adaptation is more a consequence of OCD rather than a contributing factor due to its development (or lack thereof) after symptom onset.

Limitations

In considering the results and implications of this study, several limitations should also be considered. First, while the relatively small sample size allows for the possibility that results may be more significant given a larger sample size, it also allows for the possibility that they may be less so. Participants were also not yoked for age and gender. This may contribute to apparent differences in the developmental trajectory, though it is unlikely given that the means and gender ratios were not significantly different. While the intention of this study was to examine pediatric

OCD specifically, we would also need to look at OCD in adults to see if the proposed difference in developmental trajectory continues as patients age (or if, alternatively, they catch up to their healthy counterparts).

Although faces and word case (upper or lower) were not repeated in consecutive trials, the faces were still repeated stimuli. There still may have been priming-type adaptation effects as the faces became more familiar and participants became better at the task. Several study participants commented on their perceiving the faces as ambiguous in gender and on their subjective experiences of feeling like the task got easier as they became accustomed to the faces. As a result, some slow reaction times and response errors could be attributed to stimuli confusion as opposed to stimuli congruency. This may have affected the averages for reaction times and accuracies.

While participants were positioned the same distance away from the computer monitor with the intention of keeping the amount of time that the stimuli spent on the retina constant, seating was not adjusted for other variables such as height. Additionally, participants often changed posture during the task, leading to inconsistent visual distances and angles. This effect is likely minimal, but should be considered given the millisecond specificity of response times.

Finally, the task, including the breaks between runs, was controlled entirely by the participant. As such, the lengths of the breaks, or even the number of breaks that the participants took, were not held constant. This could potentially affect accuracy and reaction time by allowing certain participants to rest more than others, giving the brain a rest or allowing the participant to lose the attention that they had given previous trials.

Conclusion

This study revealed an absence of congruency sequence effects in both OCD and healthy control youth, suggesting that the cognitive features that contribute to these do not develop until later in life. Consistent with this, the study suggests possible differences in developmental trajectories between groups in trends towards congruency sequence effects. This supports previous research showing differences in cognitive control between OCD patients and healthy children while providing insight that these difference may change over time. Future studies in this area may examine the nature of these differences by looking at variation within participants over time or treatment, providing more insight into etiologies of and interventions in pediatric OCD.

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Author Note

Jessica A. Harper, Department of Psychology, University of Michigan, Ann Arbor

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Table 1

Mean Reaction Times (RT) and Accuracies by Trial Type

Group	Measurement	Congruent trials	Incongruent trials	cC trials	cI trials	iI trials	iC trials
Control (n=15)	RT	622.7	642.5	616.3	639.1	638.1	623.9
	Accuracy	91.5%	89.0%	92.8%	88.0%	90.1%	90.0%
OCD (n = 14)	RT	607.3	622.9	595.7	619.6	616.9	604.3
	Accuracy	93.4%	90.1%	93.9%	89.4%	90.8%	92.9%

Note: 2 participants were excluded from the analysis and therefore are not included in the table.

cC trials are congruent trials preceded by congruent trials; cI, incongruent trials preceded by congruent trials; iI, incongruent trials preceded by incongruent trials; iC, congruent trials preceded by incongruent trials. Reaction times are in milliseconds.

Table 1.

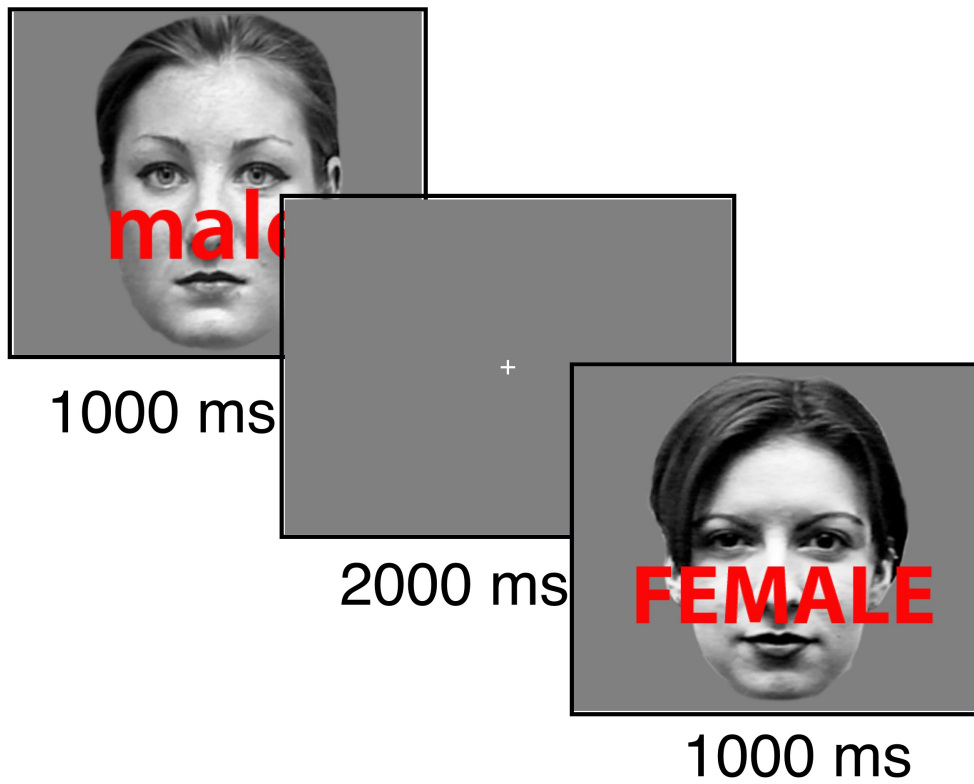


Figure 1. Timing of and incongruent (left) and congruent (right) stimulus examples from Egner's faces task.