Two faces of holistic face processing:

Facilitation and interference underlying part-whole and composite effects

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Abstract

Holistic processing, a strong tendency to process multiple features together, is regarded as a hallmark of face perception. Holistic effects can be revealed by several tasks, including the part-whole task (PW), standard composite task (SC), and complete composite task (CC). Although holistic effects are readily observed using these tasks, the lack of correlations among these effects and the mixed findings across these tasks when examining the effects among various populations or manipulations pose questions about how these effects should be understood. We distinguished facilitation and interference effects within the holistic effects in CC, and found that the holistic effect in PW appeared to be correlated with facilitation but not interference in CC, whereas the holistic effect in SC was correlated with interference but not facilitation in CC. These findings suggest that clarifying the roles of facilitation and interference is critical for understanding holistic face processing.

Key words: holistic processing, part-whole, composite faces, facilitation, interference

Public significance statement: Faces are critical for everyday social interactions and the efficiency of face processing is thought to be driven by holistic processing. Specifically, as a hallmark that distinguishes face perception from object perception, holistic processing reveals that multiple parts of a face are processed together. However, several tasks claimed to measure holistic processing do not appear to examine the same effects. This study proposes and provides evidence for a new perspective to understand the nature of holistic processing as measured in these tasks by examining facilitation and interference. Facilitation occurs when consistent information is present whereas interference occurs when inconsistent information is present. The proposed view has a strong potential to disentangle inconsistencies in the research on holistic face processing and further deepen our understanding of this hallmark of face perception, which will advance the fields of perceptual and cognitive development, perceptual expertise, and clinical cases with face processing deficits.

Faces are highly similar to each other, yet most observers are efficient in recognizing hundreds of faces and effortlessly extracting useful details about each one. Such efficiency is likely facilitated by holistic processing—a hallmark of face perception that distinguishes it from object perception—which reflects a strong tendency to process multiple facial parts together (e.g., Farah et al., 1998; Tanaka & Farah, 1993; Young et al., 1987). Corroborating evidence on holistic face processing has been accumulated from numerous studies using a variety of paradigms (for reviews, Behrmann et al., 2015; Richler & Gauthier, 2014; Rossion, 2013; Tanaka & Simonyi, 2016). It would be expected that if multiple tasks measured the same theoretical construct, performance on them should be correlated. However, among the popular tasks used to study holistic face processing (e.g., Rezlescu et al., 2017; Richler & Gauthier, 2014; Tanaka & Simonyi, 2016), performance was often found to be poorly correlated between tasks. Therefore, a unified account of holistic processing is lacking.

This study focused on three popular tasks used to measure holistic processing: the part-whole task (PW), the standard composite task (SC)[1] and the complete composite task (CC) (Figure 1). In PW (Tanaka & Farah, 1993), participants study a whole face and then are asked to identify one feature (e.g., eyes) among two choices: the correct feature along with a foil presented either in isolation or in the context of the whole face. Although the context is identical between the two whole faces, holistic processing is revealed by the part-whole effect—better

[1] We adopted the name "the standard composite task" following Rossion (2013). It has also been known as the partial design of the composite task (e.g., Richler & Gauthier, 2014).

performance in the whole relative to the isolated conditions. In SC (Hole, 1994; Young et al., 1987), participants are instructed to judge whether the top halves of two sequentially presented face composites are identical, while ignoring the bottom halves. Since the bottom halves of the two composites are always different, holistic processing is revealed by worse performance in identifying the same top halves when the top and bottom halves are aligned, compared with when they are misaligned. In CC (Farah et al., 1998; Richler et al., 2008), participants are asked to judge whether either the top or bottom halves are identical between two sequentially presented face composites. Notably, the top and bottom halves of composites in CC are either identical or different, and thus the relationship between the top and bottom halves can be congruent (both are identical or both are different) or incongruent (e.g., identical top halves and different bottom halves, or *vice versa*). Holistic processing is revealed by better performance for congruent than incongruent trials when the top and bottom halves are aligned; such difference is reduced when the halves are misaligned. In CC, the target halves are sometimes presented alone, serving as a baseline to evaluate whether facilitation or interference occurs by comparing performance between congruent and isolated trials, and between incongruent and isolated trials, respectively (e.g., Cheung & Gauthier, 2010; Richler et al., 2008).

The holistic effects in all three tasks are consistently demonstrated, and these tasks have been used extensively to study various topics related to face perception. However, these tasks also produce conflicting results. For instance, for inverted faces or other-race faces, holistic effects were reduced or minimized in PW and SC but remain robust in CC (e.g., in ethnically White samples, Rossion, 2013; Tanaka & Simonyi, 2016; Richler et al., 2011). Mixed findings across these tasks were also found regarding the extent that holistic processing contributes to face recognition ability (DeGutis et al., 2013; Konar et al., 2010; Richler, Cheung, et al., 2011; Wang et al., 2012), whether perceptual expertise increases holistic processing for non-face objects (e.g., Gauthier & Tarr, 2002; Robbins & McKone, 2007), or the extent that young children or individuals with autism show holistic processing (e.g., Crookes & McKone, 2009; de Heering et al., 2007; Gauthier et al., 2009; Joseph & Tanaka, 2003; Nishimura et al., 2008; Pellicano & Rhodes, 2003). Critically, the holistic effects measured in these three tasks do not appear to be related: specifically, no significant correlations were found between the holistic effects in PW and SC (Boutet et al., 2021; Rezlescu et al., 2017; Wang et al., 2012, but see DeGutis et al., 2013), or between the effect sizes of SC and CC (Richler & Gauthier, 2014). These findings pose serious questions about how these holistic effects should be understood to advance the understanding of face perception.

We proposed that these tasks might measure two aspects of holistic face processing—facilitation and interference (Jin, Ji, et al., 2022). As facilitation and interference can be quantified in CC by comparing performance in congruent or incongruent trials with the isolated trials (e.g., Richler et al., 2008), we suggest that the whole face context in PW provides congruent information to aid identification of the target facial feature, whereas the different bottom halves in SC produces incongruent information to impair the matching of the identical top halves. Here we investigated whether the holistic effects measured in PW and SC were specifically related to the facilitation and interference effects in CC, respectively.

Methods

Transparency and openness

The pre-registrations, data and analysis codes are available on https://osf.io/pnrwk/.

Participants

The experiment was approved by New York University Abu Dhabi Institutional Review Board. A total of 480 self-identified White adult participants completed the online study on Prolific (www.prolific.co) using Google Chrome. Following the preregistered plan, participants with RT outliers (<200ms or >5000ms) in ≥10% of one of the tasks were excluded. The remaining data from 455 participants (mean age=26.20±5.92; N female=227; N male=228), excluding the trials with RT outliers (<200ms or 3SDs of the condition; <2.2% in each task), were analyzed.

Stimuli

Figure 1 illustrates sample stimuli and trial sequences of the tasks. All faces were ethnically White. PW used stimuli from Tanaka et al. (2004) with two face templates (one female and one male), each with 6 exemplar faces with combinations of eyes, noses, and mouths from different individual faces. Composite faces for SC and CC were created using top and bottom halves from 20 female and 20 male faces from Ge et al., (2009), and Chicago Face Database (Ma et al., 2015), respectively. Isolated face halves were also included in CC.

Procedure

The experiment was programmed using jsPsych (Pinet et al., 2017) and hosted on www.pavlovia.org. All participants completed three tasks: PW, SC, and CC. The presentation order of the tasks and the assigned response keys for "same" and "different" in SC and CC were counterbalanced across participants. Practice trials with feedback were given prior to each task using line-drawing stimuli. All tasks followed the typical procedures in the literature.

In PW, participants studied a whole face and then chose from one of the two whole faces ('whole' trials) or two facial features ('part' trials) that matched the original feature. There were a total of 144 trials, with 24 trials each condition: Format: whole/part × Features: eyes/nose/mouth. On each trial, a fixation (500ms) was followed by a study face (1000ms), then by a mask (500ms), then a pair of test stimuli.

In SC, participants judged whether two sequentially presented face composites showed the same top half. The top halves were cued with a bracket on both composites. The face halves were either aligned or misaligned. The top halves were identical in half of the trials and were different in the rest of the trials. The bottom halves were always different. There were a total of 160 trials, with 40 trials in each of the Alignment (aligned/misaligned) by Correct Response (same/different) condition. On each trial, a fixation was followed by a study composite (500ms), then by a mask (500ms), and then by a test composite.

In CC, participants judged whether the cued halves (top or bottom) of two sequentially presented face composites were identical. The relationship between top and bottom halves were either congruent (both halves were identical, or both were different) or incongruent (e.g., same top halves and different bottom halves, or *vice versa*). The face halves were either aligned or misaligned; the target halves were also presented in isolation as the baseline. There were a total of 400 trials, with 20 trials in each condition with full composites (Cue: top/bottom; Congruency: congruent/incongruent; Alignment: aligned/misaligned; Correct response: same/different) and for isolated halves (Cue × Correct Response). On each trial, a fixation was followed by a study composite (500ms), then by a mask (500ms), and then a test stimulus (composite or isolated half, with the target half cued by a bracket).

Analysis

Analyses were conducted using R (v4.1.3) on accuracy/choice and RT data with generalized linear mixed-effects models with one-sided tests. All results are reported with corrections of multiple comparisons applied, except otherwise noted. Reliability results of the measures are reported in Table 1.

First, to replicate the holistic effects observed in each task and examine the correlations among the holistic effects across tasks, we examined 1) the part-whole effect comparing performance between wholes and parts (eyes/mouth only, Crookes et al., 2013; Joseph & Tanaka, 2003); 2) the standard composite effect comparing performance in the *same* trials between aligned and misaligned composites (Boutet et al., 2021; Rezlescu et al., 2017); 3) the complete composite effect comparing performance using all trials in alignment and congruency conditions (Jin, Oxner, et al., 2022; Richler, Mack, et al., 2011). The holistic effects were computed by subtracting or regressing out performance of a condition that was expected to engage less or minimal holistic processing from another condition that was expected to engage holistic processing: part trials from whole trials for PW, misaligned trials from aligned trials for SC, and congruency effect in misaligned trials from congruency effect in aligned trials for CC (DeGutis et al., 2013; Rezlescu et al., 2017). Correlations were then performed on the holistic effects without multiple comparison corrections (Boutet et al., 2021; DeGutis et al., 2013; Rezlescu et al., 2017; Wang et al., 2012).

Second, facilitation and interference in CC was revealed by differences in performance between isolated trials (baseline) and congruent trials for aligned composites, and between isolated trials and incongruent trials for aligned composites, respectively (Gregory et al., 2021; Richler, Bukach, et al., 2009; Richler, Cheung, et al., 2009; Richler et al., 2008; Cheung & Gauthier, 2010). Correlations were performed between the facilitation effect in CC and the holistic effect in PW, and between the interference effect in CC and the holistic effect in SC. Moreover, to examine the specificity of the relationship, correlations were also performed between the interference effect in CC and the holistic effect in PW, and between the facilitation effect in CC and the holistic effect in SC, as non-preregistered analyses.

Results

Holistic effects across tasks and their relationships

Holistic effects were observed in all tasks (Figure 2; Table 2). In PW, performance was better (z=12.02, p<.001) and faster (z=-2.81, p=.003) for wholes than parts. In SC, performance was worse (z=-9.93, p<.001) and slower (z=7.93, p<.001) for aligned than misaligned composites. In CC, the congruency effect was found for aligned composites, with higher *d*' (z=31.95, p<.001) and shorter RT (z=-15.62, p<.001) for congruent than incongruent trials, and larger congruency effects for aligned than misaligned composites, as indicated by the interaction between Congruency and Alignment in *d*' (z=18.97, p<.001) and RT (z=-9.41, p<.001).

No significant correlations were observed between PW and SC ($|r|<.06$, $p>.21$), or between PW and CC (except a marginal effect in d'/accuracy with regression without corrections, $r(453)=.08$, $p=.07$, all others: $|r|<.04$, $p>.46$). Nonetheless, significant correlations were observed among the holistic effects between SC and CC for choices using either subtraction: $r(453)=.12$, $p=.013$ or regression: $r(453)=.15$, $p=.001$, though not for RT ($|r|<.08$, $p>.13$).

Facilitation and interference in CC and their relationships with holistic effects in PW and SC

Facilitation and interference were observed in CC (Figure 2; Table 2): Facilitation was revealed by higher *d*' for aligned-congruent than isolated trials ($z=10.17$, $p<.001$), though not significantly faster in RT ($z=9.86$, $p>.99$). Interference was observed with lower *d*' ($z=-20.33$, $p<.001$) and longer RT ($z=21.91$, $p<.001$) for aligned-incongruent than isolated trials.

Correlation analyses (Figure 3; Table 3) revealed a significant correlation between facilitation in CC in *d*' and the holistic effect in PW in accuracy using regression, when no correction for multiple comparisons was applied, $r(453)=.09$, $p=.035$, but not when Holm corrections for 4 tests was applied: $p_{adjusted}=.14$; no other correlations were found $|r\text{'s}|<.05$, $p\text{'s}>.15$. Conversely, interference in CC in *d*' (Figure 4; Table 3) was significantly correlated with the holistic effect in SC in accuracy using either subtraction, $r(453)=.16$, $p<.001$, $p_{adjusted}<.001$ or regression, $r(453)=.24$, $p<.001$, $p_{adjusted}<.001$; no significant results were observed in RT (subtraction: $r(453)=.08$, $p=.055$, $p_{adjusted}=.11$; regression: $r(453)=.05$, $p=.14$). There were no significant correlations between facilitation in CC and the holistic effect in SC, $|r|<.07$, $p>.15$ or between interference in CC and holistic effects in PW, $|r|<.07$, $p>.15$.

Discussion

As expected, robust holistic effects were found in all three tasks: PW, SC, and CC. Replicating previous findings, we found no significant correlations between the holistic effects in PW and those in either SC or CC (Boutet et al., 2021; Rezlescu et al., 2017; Wang et al., 2012; but see DeGutis et al., 2013), despite a large sample being used. Nonetheless, when directly comparing the holistic effects measured in SC and CC, this study was the first to show significant correlations between these effects. Although all three tasks are designed to measure holistic processing, the lack of significant correlations among PW with either SC or CC might not be surprising since PW is more different than SC and CC on both stimulus manipulations (e.g., whole-part vs. halves) and task requirements (e.g., two-alterative forced choice vs. sequential matching). Importantly, we found that the holistic effect in PW was only correlated with the facilitation, but not interference, effect measured in CC, in the likely most robust condition with *d'*/accuracy (Richler & Gauthier, 2014) using regression (DeGutis et al., 2013; but see Ross et al., 2015). Conversely, the holistic effect in SC was correlated with the interference, but not facilitation, effect measured in CC. These findings suggest that the two components of holistic processing measured in CC, facilitation and interference, are likely differentially related to the holistic effects measured in PW and SC.

Our results suggest that it is crucial to understand holistic processing in terms of facilitation and interference across these widely used tasks. Facilitation and interference have been discussed as the two sides of a coin for holistic processing (Tanaka & Simonyi, 2016) and the two components can be readily distinguished in the congruency effect measured in CC (Cheung & Gauthier, 2010; Richler et al., 2008). Naturally, facial features co-vary and consistent information on faces is almost always expected in our daily life. For instance, when seeing a big smile on someone's face, scrunched eyes or dimples are often expected. Inconsistent information, such as a combination of eyes filled with sadness and a big smile, or facial features from different individuals, is highly unexpected. As observers learn such regularities among facial features throughout their lifetime, holistic processing—an efficient way to process as much information as possible on a face—is highly useful for face recognition. Thus, it is conceivable that congruent facial information in PW and CC generally facilitates recognition. Moreover, the experimental manipulations with incongruent face halves in CC and SC are robust demonstrations of the strong tendency of processing all facial information together, as the unexpected inconsistencies greatly impair recognition.

Consistent with recent findings that facilitation and interference in holistic face processing may operate somewhat independently (Jin, Ji, et al., 2022), our results suggest that the separate contributions from facilitation or interference in PW, SC, and CC might have resulted in the mixed findings in the literature. Because both facilitation and interference that contribute to the holistic effect can be measured by the congruency effect in CC, we suggest that CC may be a more complete measure of holistic processing than the other tasks if both components of holistic processing are of interest. Moreover, future studies should also investigate whether and how the relationship among the holistic effects and their components in these tasks might be affected when further manipulations are introduced or when diverse or clinical populations are tested. Note also that while this study compared these tasks in their most widely used formats, these tasks were originally designed to measure group-level results. Although the reliability of our measures was improved following previous recommendations (Ross et al., 2015), future studies may consider adopting versions of these tasks optimized to study individual differences (Richler et al., 2015; but see Sunday et al., 2017).

In sum, this study shows the importance to study holistic processing of faces in terms of facilitation from consistent information and interference from inconsistent information. Both effects are readily measured in CC, and these components are differentially related to the holistic effects in PW and SC. Our findings help clarify the relationship among these widely used tasks for studying holistic processing and have a great potential for resolving some mixed findings in the literature and for advancing the field to elucidate the nature of holistic processing.

Authors' contributions

Haiyang Jin: conceptualization, methodology, resources, software, investigation, data curation, formal analysis, validation, visualization, writing – original draft, writing – review and editing.

William G. Hayward: conceptualization, writing – original draft, writing – review and editing, funding acquisition.

Olivia. S. Cheung: conceptualization, methodology, resources, writing – original draft, writing – review and editing, visualization, supervision, funding acquisition.

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Table 1. Reliability of each condition in the part-whole task, the standard composite task, and the complete composite task, and reliability of the holistic effects in the three tasks and the facilitation and interference effects in the complete composite task calculated using difference scores or regression residuals.

Task	DV	Condition/Effect	Method	Reliability
Part-whole task (PW)	accuracy	whole	Guttman's λ_2	0.81
	accuracy	part	Guttman's λ_2	0.72
	RT	whole	Guttman's λ_2	0.94
	RT	part	Guttman's λ_2	0.94
	accuracy	holistic effect: whole - part	Subtraction	0.27
	accuracy	holistic effect: whole ~ part	Regression	0.41
	RT	holistic effect: whole - part	Subtraction	0.77
	RT	holistic effect: whole ~ part	Regression	0.79
Standard composite task (SC)	accuracy	aligned	Guttman's λ_2	0.84
	accuracy	misaligned	Guttman's λ_2	0.89
	RT	aligned	Guttman's λ_2	0.93
	RT	misaligned	Guttman's λ_2	0.95
	accuracy	holistic effect: ali - mis	Subtraction	0.47
	accuracy	holistic effect: ali ~ mis	Regression	0.50
	RT	holistic effect: ali - mis	Subtraction	0.62
	RT	holistic effect: ali ~ mis	Regression	0.63
Complete composite task (CC)	*d'*	con_ali	Guttman's λ_2	0.77
	d'	inc_ali	Guttman's λ_2	0.71
	d'	con_mis	Guttman's λ_2	0.74
	d'	inc_mis	Guttman's λ_2	0.75
	d'	isolated	Guttman's λ_2	0.77
	RT	con_ali	Guttman's λ_2	0.96
	RT	inc_ali	Guttman's λ_2	0.96
	RT	con_mis	Guttman's λ_2	0.96
	RT	inc_mis	Guttman's λ_2	0.96
	RT	isolated	Guttman's λ_2	0.96
	d'	holistic effect: (con_ali - inc_ali) - (con_mis - inc_mis)	Subtraction	0.19
	d'	holistic effect: (con_ali - inc_ali) ~ (con_mis - inc_mis)	Regression	0.42
	RT	holistic effect: (con_ali - inc_ali) - (con_mis - inc_mis)	Subtraction	0.49
	RT	holistic effect: (con_ali - inc_ali) ~ (con_mis - inc_mis)	Regression	0.59
Facilitation in CC	*d'*	con_ali - isolated	Subtraction	0.18
	d'	con_ali ~ isolated	Regression	0.28
	RT	con_ali - isolated	Subtraction	0.61
	RT	con_ali ~ isolated	Regression	0.60
Interference in CC	*d'*	inc_ali - isolated	Subtraction	0.35
	d'	inc_ali ~ isolated	Regression	0.37
	RT	inc_ali - isolated	Subtraction	0.70
	RT	inc_ali ~ isolated	Regression	0.67

***Note*. “DV” denotes dependent variables. “RT” denotes correct response times. “Condition/Effect” denotes the condition or effect for which the reliability was calculated, where con=congruent, inc=incongruent, ali=aligned, mis=misaligned, and “-“ and “~” refers to the difference scores or regression residuals between the conditions, respectively. “Method” denotes to the method used to calculate the reliability using either the difference scores (“subtraction”, Rogosa et al., 1982) or regression residuals (“regression”, Malgady & Colon-Malgady, 1991).**

Table 2. Inferential statistics on the holistic effects in the part-whole task, the standard composite task, and the complete design task, and the facilitation and interference effects in the complete composite task.

Effects	DV	EMM	Inferential statistics
Holistic effects in PW	accuracy	whole=91.5%	*z* =12.02, *p* <.001
		part=81.8%	Odds Ratio = 2.39, 95% *CI* = [2.12 Inf]
	RT	whole=1206	*z* =-2.81, *p* =.003
		part=1245	Ratio = 0.97, 95% *CI* = [0 0.99]
Holistic effects in SC	accuracy	ali=89.0%	*z* =-9.93, *p* <.001
		mis=95.2%	Odds Ratio = 0.41, 95% *CI* = [0 0.47]
	RT	ali=708	*z* =7.93, *p* <.001
		mis=653	Ratio =1.08, 95% *CI* = [1.07 Inf]
Holistic effects in CC	*d*'	ali_con=2.18	(1) *z* =31.95, *p* <.001
		ali_inc=1.08	β = 1.11, 95% *CI* = [1.05 Inf]
		mis_con=1.91	(2) *z* =18.97, *p* <.001
		mis_inc=1.44	β = 0.64, 95% *CI* = [0.59 Inf]
	RT	ali_con=877	(1) *z* =-15.62, *p* <.001
		ali_inc=931	Ratio = 0.94, 95% *CI* = [0 0.95]
		mis_con=903	(2) *z* =-9.41, *p* <.001
		mis_inc=920	Ratio = 0.96, 95% *CI* = [0 0.97]
Facilitation in CC	*d*'	ali_con=2.19	*z* =10.17, *p* <.001
		isolated=1.74	β = 0.45, 95% *CI* = [0.38 Inf]
	RT	ali_con=877	*z* =9.86, *p* >.99
		isolated=844	Ratio = 1.04, 95% *CI* =[0 1.05]
Interference in CC	*d*'	ali_inc=1.08	*z* =-20.33, *p* <.001
		isolated=1.74	β=-0.66, 95% *CI* = [-Inf -0.61]
	RT	ali_inc=930	*z* =21.91, *p* <.001
		isolated=844	Ratio = 1.10, 95% *CI* = [1.09 Inf]

***Note*. "DV" denotes dependent variables. "RT" denotes response times. "EMM" denotes the estimated marginal means for each condition, where ali=aligned, mis=misaligned, con=congruent, and inc=incongruent. CI=Confidence Intervals. For odds ratio or ratio, the null value in the statistical null hypothesis is 1. For the complete composite results, (1) show the congruency effect (i.e., differences between congruent and incongruent trials) for aligned composites, and (2) show the interaction between Congruency and Alignment. As pre-registered, one-sided tests were used in these analyses (https://osf.io/pnrwk/).**

Table 3. Correlations among the holistic effects, and correlations among the facilitation and interference in complete composite task and the holistic effects in the part-whole task and the standard composite task.

Effects	Method	DV	r	95% CI	p-value	p-Holm	Upper bound for r
Holistic effects in PW vs. SC	subtraction	accuracy	0.06	[-0.03 0.15]	0.22	-	0.36
	subtraction	RT	-0.01	[-0.10 0.08]	0.80	-	0.69
	regression	accuracy	0.01	[-0.08 0.10]	0.88	-	0.45
	regression	RT	-0.04	[-0.13 0.06]	0.45	-	0.70
Holistic effects in CC vs. PW	subtraction	*d*'/ accuracy	0.03	[-0.06 0.13]	0.47	-	0.23
	subtraction	RT	0.03	[-0.06 0.13]	0.47	-	0.61
	regression	*d*'/ accuracy	0.08	[-0.01 0.18]	0.071	-	0.42
	regression	RT	-0.005	[-0.10 0.09]	0.94	-	0.68
Holistic effects in CC vs. SC	subtraction	*d*'/ accuracy	0.12	[0.02 0.21]	0.013*	-	0.30
	subtraction	RT	-0.005	[-0.09 0.09]	0.96	-	0.55
	regression	*d*'/ accuracy	0.15	[0.06 0.24]	0.0011*	-	0.46
	regression	RT	0.07	[-0.02 0.16]	0.13	-	0.61
Facilitation in CC vs. Holistic effect in PW	subtraction	*d*'/ accuracy	0.05	[-0.03 1.00]	0.16	0.47	0.22
	subtraction	RT	-0.01	[-0.09 1.00]	0.38	0.75	0.68
	regression	*d*'/ accuracy	0.09	[0.01 1.00]	0.035*	0.14	0.34
	regression	RT	0.01	[-0.07 1.00]	0.40	0.75	0.69
Interference in CC vs. Holistic effect in SC	subtraction	*d*'/ accuracy	0.16	[0.09 1.00]	< .001*	< .001**	0.41
	subtraction	RT	0.08	[0.00 1.00]	0.055	0.11	0.66
	regression	*d*'/ accuracy	0.24	[0.17 1.00]	< .001*	< .001**	0.43
	regression	RT	0.05	[-0.03 1.00]	0.14	0.14	0.65
Facilitation in CC vs. Holistic effect in SC	subtraction	*d*'/ accuracy	0.07	[-0.02 0.16]	0.15	0.60	0.29
	subtraction	RT	0.01	[-0.09 0.10]	0.89	0.99	0.61
	regression	*d*'/ accuracy	0.05	[-0.05 0.14]	0.32	0.95	0.37
	regression	RT	-0.01	[-0.11 0.08]	0.77	0.99	0.61
Interference in CC vs. Holistic effect in PW	subtraction	*d*'/ accuracy	-0.06	[-0.15 0.03]	0.22	0.65	0.31
	subtraction	RT	0.03	[-0.06 0.12]	0.48	0.97	0.74
	regression	*d*'/ accuracy	-0.07	[-0.16 0.02]	0.15	0.61	0.39
	regression	RT	-0.002	[-0.09 0.09]	0.98	0.98	0.73

***Note*. PW=part-whole task, SC=standard composite task, CC=complete composite task. "Method" denotes the method used to calculate the holistic effects. "DV" denotes dependent variables (RT=response times). "r" shows the Pearson's correlation coefficient. "95% CI" shows the lower and upper boundaries of the 95% confidence intervals. "p-value" and "p-adjust" denote the p-value without corrections and with Holm corrections (for four tests). "Upper bound for r" denotes the potential ceiling of the correlation, which is the square root of the product of the two measurements' reliabilities.**

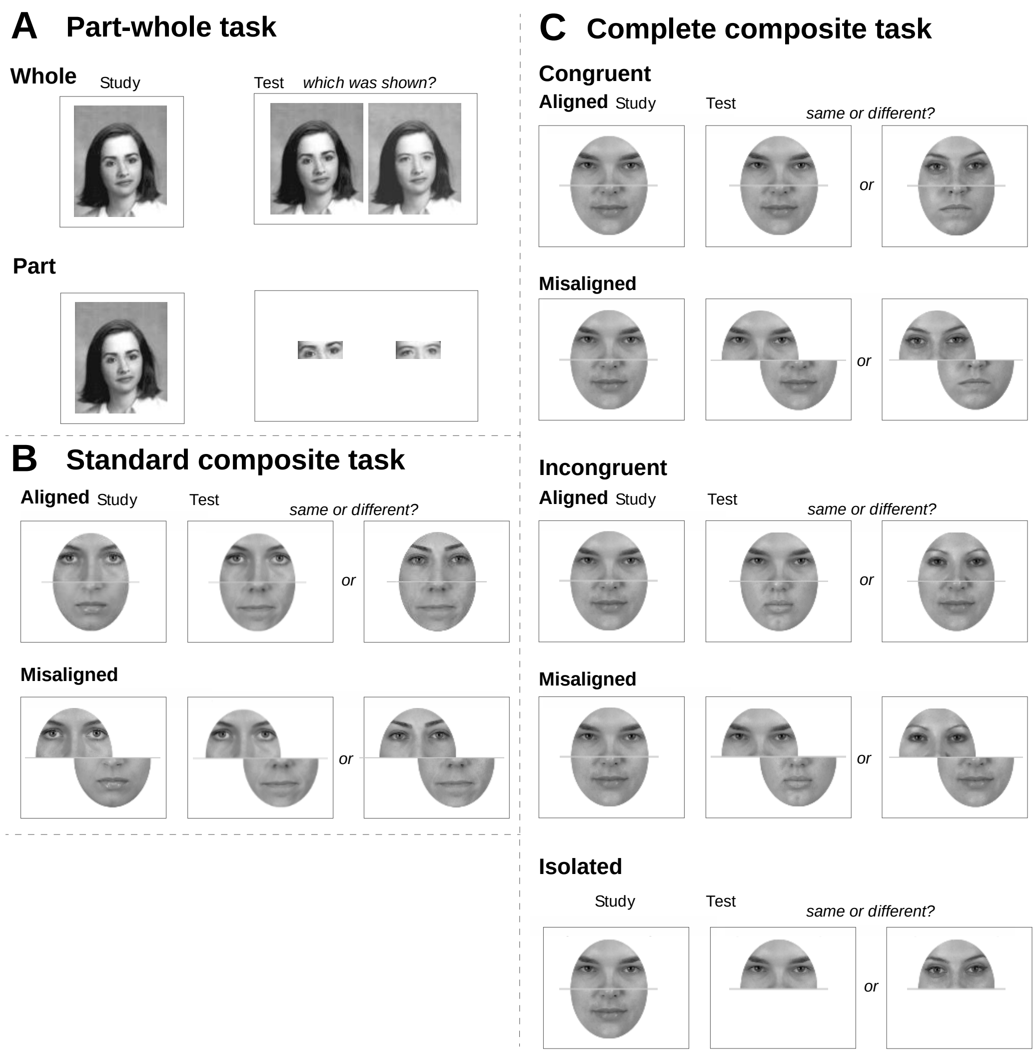

Figure 1. Designs and trial sequences of the three tasks: the part-whole task (Figure 1A), and the standard composite task (Figure 1B), and the complete composite task (Figure 1C). In this illustration of the complete composite task, the top halves are the target halves.

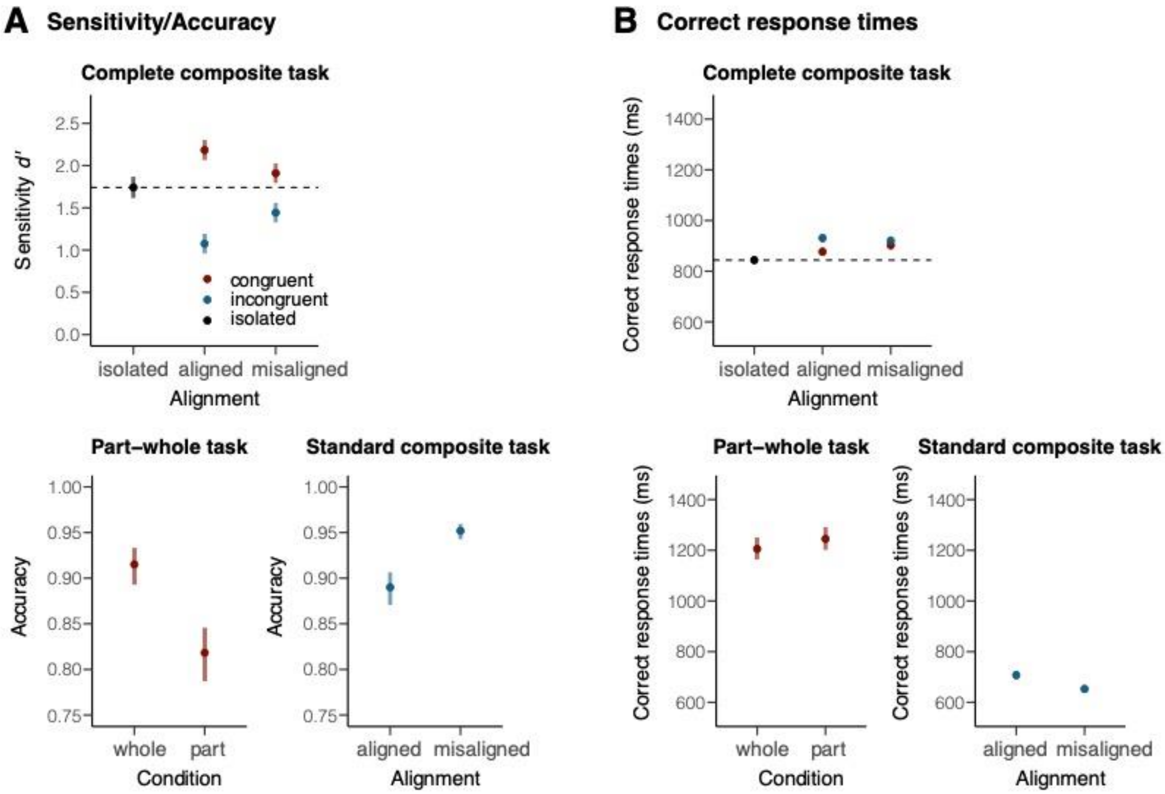

Figure 2. Holistic effects in the three tasks, and facilitation and interference effects in the complete composite task (facilitation: aligned-congruent minus isolated; interference: aligned-misaligned minus isolated). Figure 2A illustrates the results on choice (*d'* for the complete composite task, and accuracy for the part-whole task and the standard composite task) and Figure 2B illustrates the results in correct response times. Error bars denote the 95% confidence intervals.

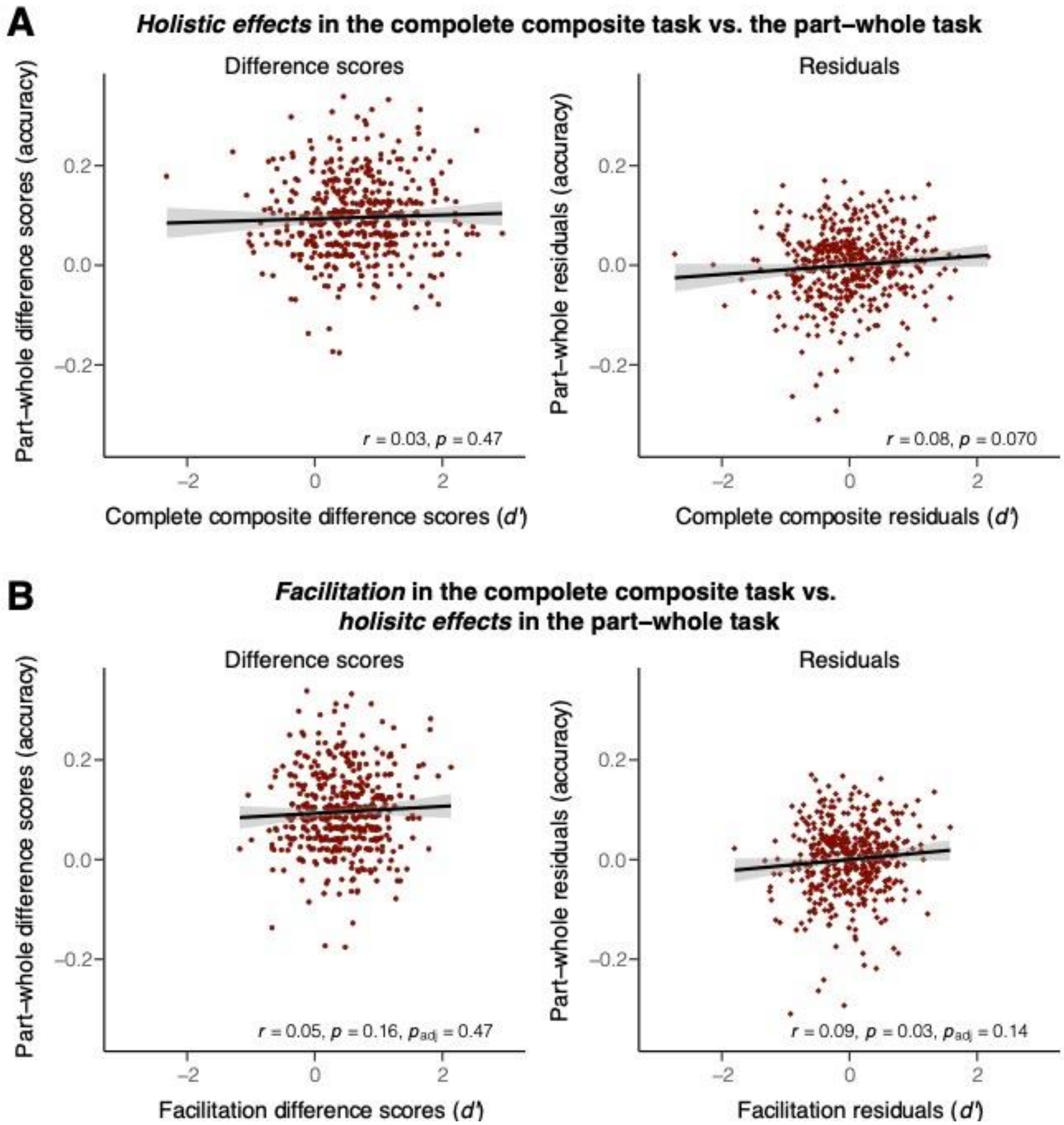

Figure 3. Figure 3A: Correlation results between the holistic effects in the complete composite task (*d′*) and the part-whole task (accuracy). Figure 3B: Correlation results between the facilitation effects in the complete composite task (*d′*) and the holistic effects in the part-whole task (accuracy). The gray regions indicate the 95% confidence intervals of the fitted line.

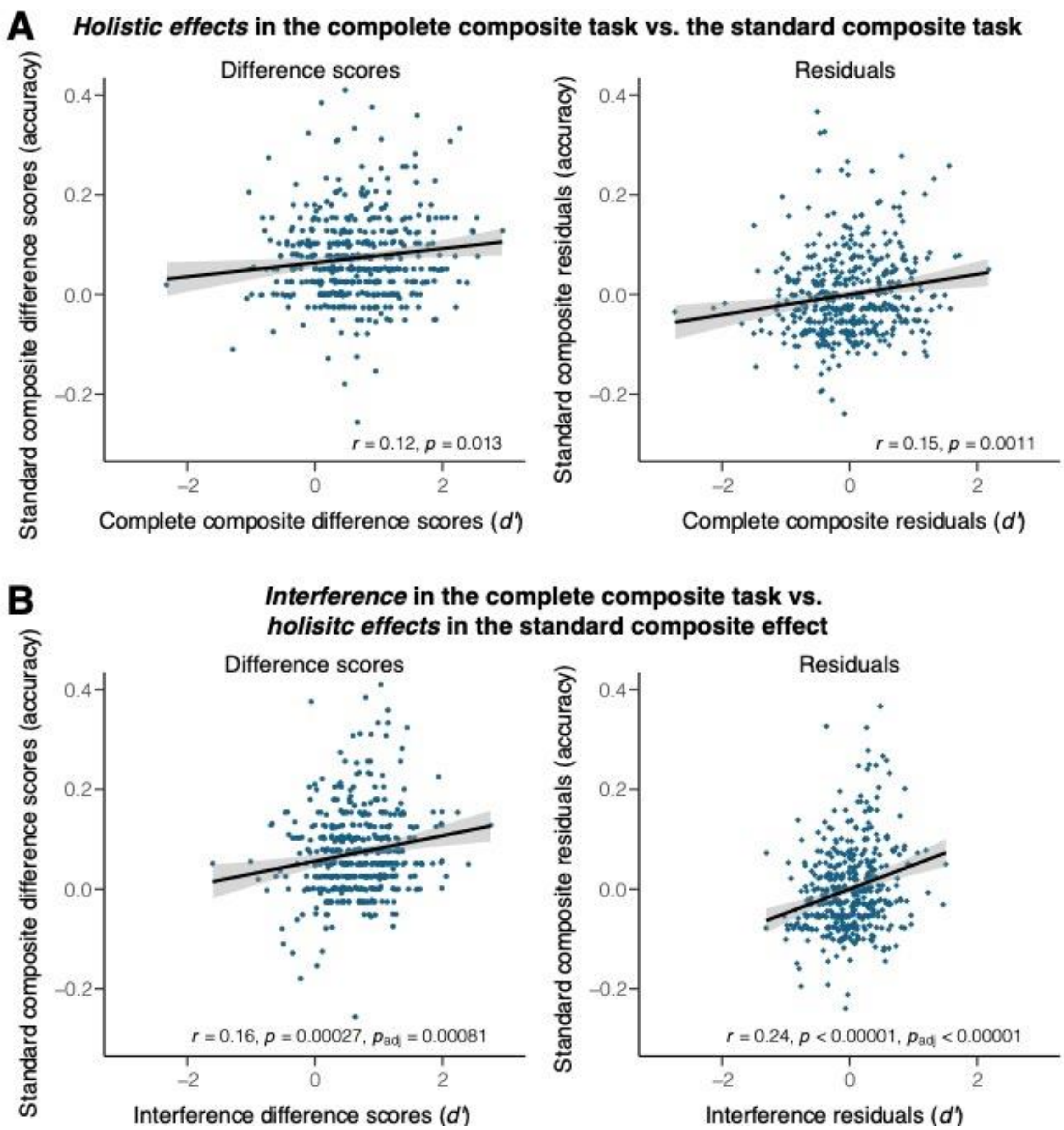

Figure 4. Figure 4A: Correlation results between the holistic effects in the complete composite task (d') and the standard composite task (accuracy). Figure 4B: Correlation results between the interference effects in the complete composite task (d') and the holistic effects in the standard composite task (accuracy). The gray regions indicate the 95% confidence intervals of the fitted line.