

Journal of Experimental Psychology: General

What You See Depends on What You Hear: Temporal Averaging and Crossmodal Integration

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Online First Publication, September 13, 2018. <http://dx.doi.org/10.1037/xge0000487>

CITATION

Chen, L., Zhou, X., Müller, H. J., & Shi, Z. (2018, September 13). What You See Depends on What You Hear: Temporal Averaging and Crossmodal Integration. *Journal of Experimental Psychology: General*. Advance online publication. <http://dx.doi.org/10.1037/xge0000487>

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L C X Z
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U f M B
C U f L

Z S
L W M U f M

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O f f f f f f f
f f T w f f
w u u I w f f
u u f u w u
u f f T f T
u u w T f W f
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K
B

M
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O (C & V, 2013; O
B, Z, & R, 2012; R, 2009; S, &
R, 2001): w f w

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L C C B C S P
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S S f P C S B K
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P (M f E), PKU-IDG/MG I f
B R P U H J M D P
L W M U f M D f P
S B C U f L Z S
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f u f u u (K, L, B, & W, 2011). T w
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A (G, G, & B, 2005).
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(B, 2017; G & M w, 1959; K, 1945; S, 1964):
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f w
(R, 2003). Q
f B f
(R, H, & M w, 2006), w
w
A ff
ff f
(M, C, & H, 1981)
f (W, D, H, & W, 1986),
ff f
(B, D, R, & M, 2013).
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A, 2001)

u u f u u ; f
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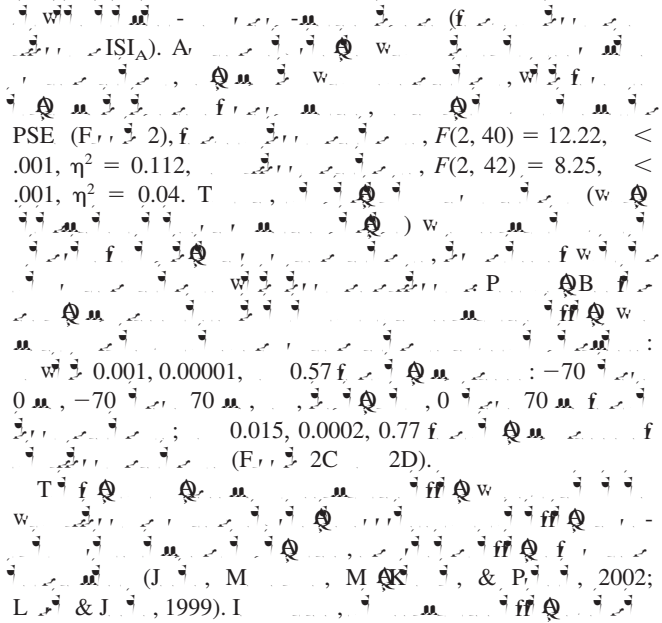
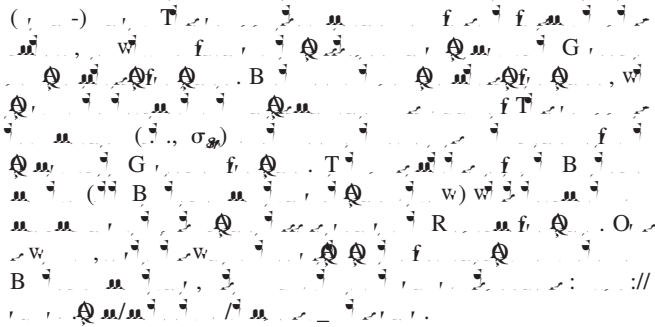
(ISI_V) (w, f 50), ISI_V (f 230; F, 1A 1B).
 ISI_A (f ISI_A; S, 2010).
 C & V, 2013). H, T (F, 1C;)
 E 1 w, I E 2, w, I E 3, w, I E 4, w, AM GM f A E 5 w, T F, w, B (E. & B, 2002; R, 2006).

Materials and Method

Participants

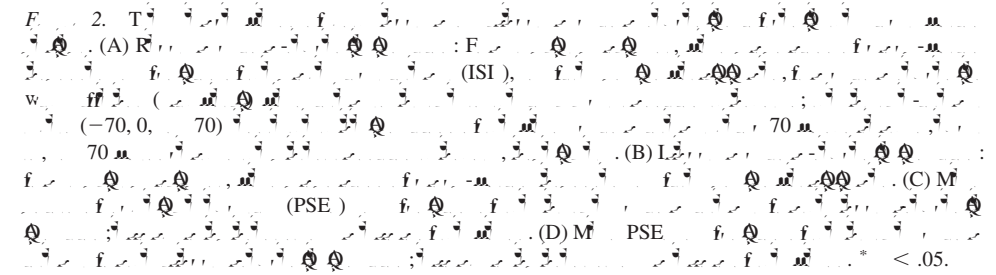
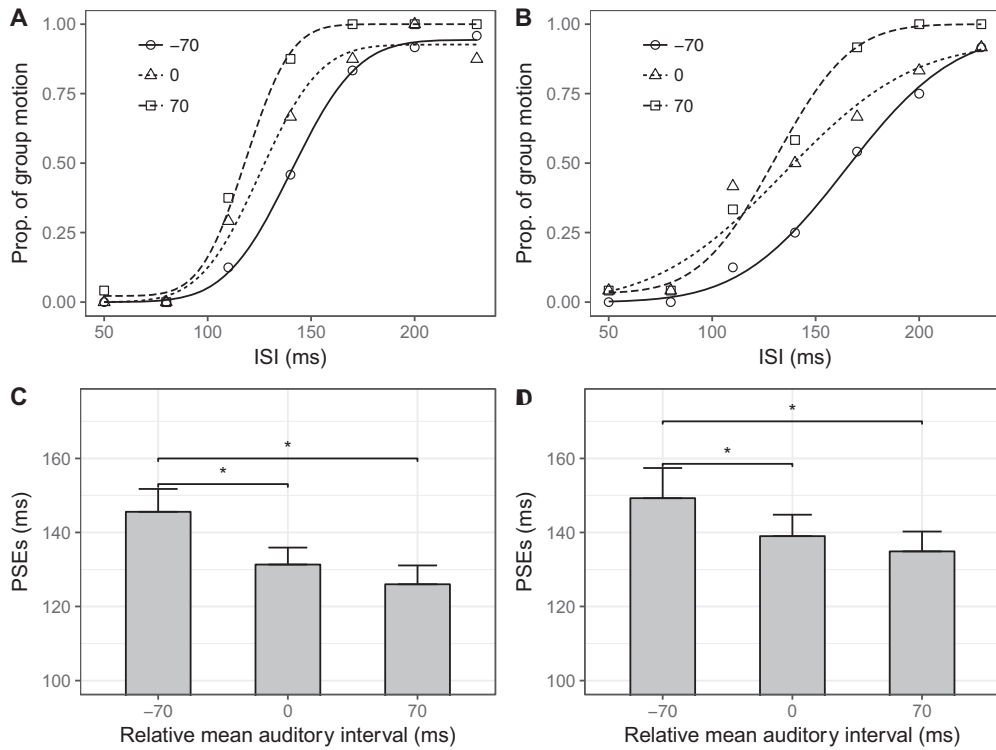
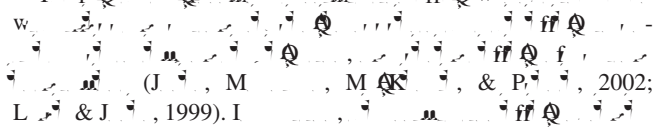
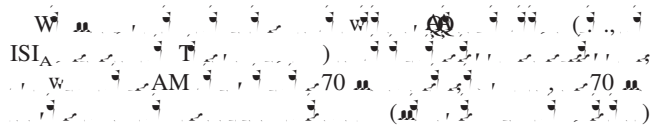
A f 84 (21, 22, 16, 12, 12 E 1 5; f, 18, 33) A T w, A Aff C f D f P, P U (f #P, [2012-03-

$T = 40$ f ISI_v P
 w f- w T P
 f 280 f 70
 Af (D A M). T
 (PSE)
 w ISI
 f 50% f T
 (JND), w f f
 ff (25%) (75%) f
Main experiments. I
 w T
 f 6, 8 w (w f f f
 T). A f w T
 f (f 30 μ) w (30-μ)
 (, ISI_v



Results

Experiments 1 and 2: Both Regular and Irregular Auditory Intervals Alter the Visual Motion Percept

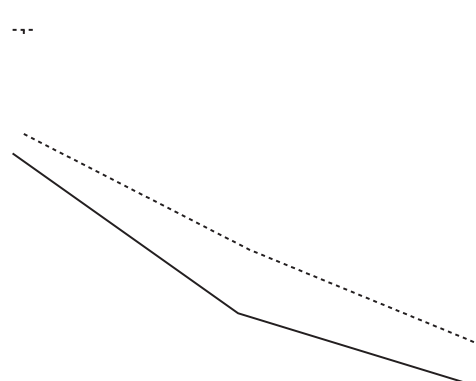


T... f... ff...
 F(1, 22) = 2.14, $\eta^2 = .15$. A...
 F... JND ($\pm E$) f...
 ISI_v (34.9 [± 3.1], 30.5 [± 3.4], 28.4
 [± 2.9] μ s, ISI_v 70...
 JND f... (18.8 [± 1.2] μ s;
 = .001, = .002, = .033 f...
 (>0.1). T... f...
 JND f 31.8 (± 3.2), = .001, 30.6 (± 2.3), = .005, 27.2
 (± 2.2) μ s, 18.6 (± 2.1) μ s, w...
 (>0.1). T... w...

Experiment 3: Variability of Auditory Intervals Influences Visual Ternus Apparent Motion

A... f...
 (E... & D L..., 2011; S..., C..., & M..., 2013),
 f... ff... w...
 f... f... A...
 w... w... w...

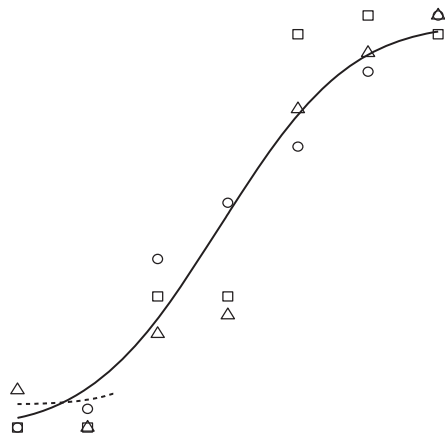
T... ff... f... w... f... F(2, 30) =
 11.8, < .001, $\eta^2 = 0.078$, w...
 f... PSE: PSE f 132 \pm 4.6 μ s),
 PSE: PSE f 147 \pm 6.7 μ s),
 PSE f 138 \pm 5.3 μ s). P... B... E... 1... 2:
 f... ff... w... (<
 .01) (< .001), w...
 (= .49). I...
 f CV w... f... F(1,
 15) = 5.29, < .05, $\eta^2 = 0.044$, w...
 CV w... F(2, 30) = 0.31, = .73, $\eta^2 =$
 0.0008 (F... 3). F... f...
 f... ff... w...
 f... f... ff... w...
 f... f... f... F(1, 15) = 0.33, =
 .55.



T... w... F... B... M...
 B... M...
 (B...
 1999; S... 2013), w...
 F... 2 w...
 w... CV...
 CV... T...
 B... M... S...
 w... f... PSE...
 CV...
 (f...)
 AM... A... CV...
 w... GM... E...
 4 w...
 GM... AM...

Experiment 4: Perceptual Averaging of Auditory Intervals Assimilates the Visual Interval Toward the GM Rather Than the AM

I E... 4, w...
 T... A.M... G M... T PSE
 w... 136 (±5.46), 148 (±6.17), 136 (±6.2) ... A.M,



G M... F(2, 22) =
 8.81, < .05, $\eta^2 = 0.08$ (F... 4). B f...
 G M... w... < .01,
 w... w... ff... w... A.M...
 = 1. T...
 GM... AM...

Experiment 5: Auditory Sequences With the Last Interval Fixed

I E... 1 3, w...
 (T...) f...
 w...
 I E... 5,
 w... f...
 (w...)
 GM... F... 5... f...
 E... 5. T PSE w... 153.1 (±7.3)
 , 137.9 (±9.1) f...
 (11) = 3.640, < .01. T... w...
 I... w...
 T... T...
 G... w... f...

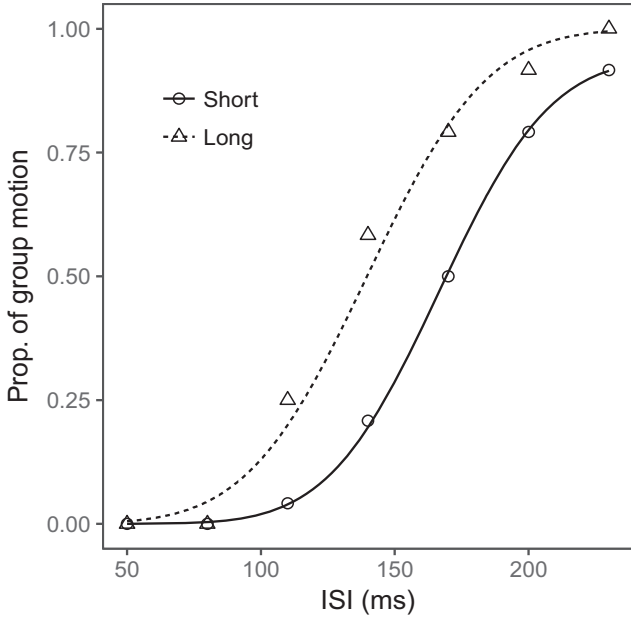


Figure 5. Mean ISI (ms) for short (solid line) and long (dashed line) group motion. Error bars represent standard error. The x-axis is ISI (ms) and the y-axis is the proportion of group motion.

Bayesian Modeling

Bayesian modeling was used to estimate the parameters of the ISI distribution. The ISI (I) is assumed to follow a normal distribution with mean μ and variance σ^2 . The probability of group motion (P_g) is assumed to follow a normal distribution with mean μ_g and variance σ_g^2 . The likelihood function is given by:

$$I = \mu + \sigma \epsilon, \quad (1)$$

where ϵ is a standard normal random variable. The posterior distribution is estimated using Markov Chain Monte Carlo (MCMC) sampling. The mean and standard deviation of the posterior distribution are reported in Table 1.

The mean ISI for short group motion is approximately 110 ms, and for long group motion is approximately 140 ms. The standard deviation of the ISI is approximately 40 ms for short group motion and 50 ms for long group motion.

$$P_g \sim -(\mu_g - I)^2 / \sigma_g^2, \quad (2)$$

where σ_g^2 is the variance of the posterior distribution of P_g .

The ISI distribution is estimated using MCMC sampling. The mean and standard deviation of the posterior distribution are reported in Table 1.

$$I = P_g I + (1 - P_g) I. \quad (3)$$

The ISI distribution is estimated using MCMC sampling. The mean and standard deviation of the posterior distribution are reported in Table 1.

$$I = (1 - P_g) I + P_g I. \quad (4)$$

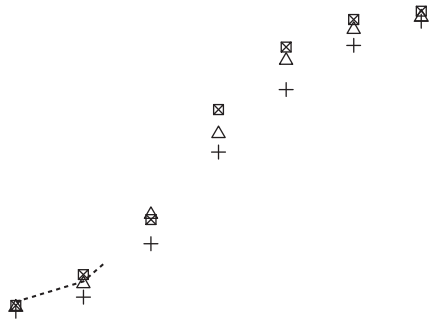
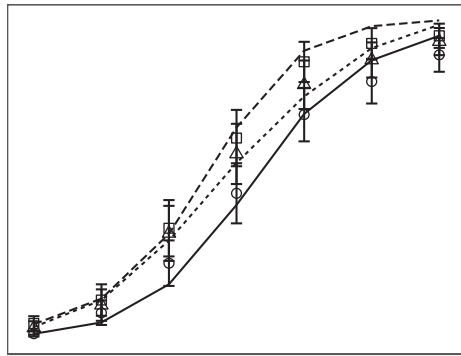
The ISI distribution is estimated using MCMC sampling. The mean and standard deviation of the posterior distribution are reported in Table 1. The BIC and R^2 values are also reported in Table 1. The BIC values are -1,859 for the ISI distribution, -1,392 for the P_g distribution, and -2,894 for the joint distribution. The R^2 values are 0.86 for the ISI distribution, 0.91 for the P_g distribution, and 0.91 for the joint distribution.

The ISI distribution is estimated using MCMC sampling. The mean and standard deviation of the posterior distribution are reported in Table 1. The BIC and R^2 values are also reported in Table 1. The BIC values are -1,859 for the ISI distribution, -1,392 for the P_g distribution, and -2,894 for the joint distribution. The R^2 values are 0.86 for the ISI distribution, 0.91 for the P_g distribution, and 0.91 for the joint distribution.

Table 1. Mean and standard deviation of the posterior distribution of the ISI and P_g parameters. The BIC and R^2 values are also reported.

E	P		F		ΔBIC
	BIC	R^2	BIC	R^2	
I	-1,859	.86	-1,392	.63	467
P_g	-1,932	.91	-1,772	.88	160
I, P_g	-2,894	.91	-2,878	.91	16

The BIC values are -1,859 for the ISI distribution, -1,392 for the P_g distribution, and -2,894 for the joint distribution. The R^2 values are 0.86 for the ISI distribution, 0.91 for the P_g distribution, and 0.91 for the joint distribution. The ΔBIC values are 467 for the ISI distribution, 160 for the P_g distribution, and 16 for the joint distribution.



T f w F, 7, w A w F f 0 () 140 (134.6 f w 144.8 f w). F f 70 w, f -70 B w PSE F, 8 PSE f L f -0.978 R² T f f 6% E 1 2 () w f 1), w PSE T w w

w R² (T 1). T w BIC w

General Discussion

U T w f w (-) T W f (E 1) (E 2 3) f T f w I E 4, w f GM f AM. F () (E 5) f f

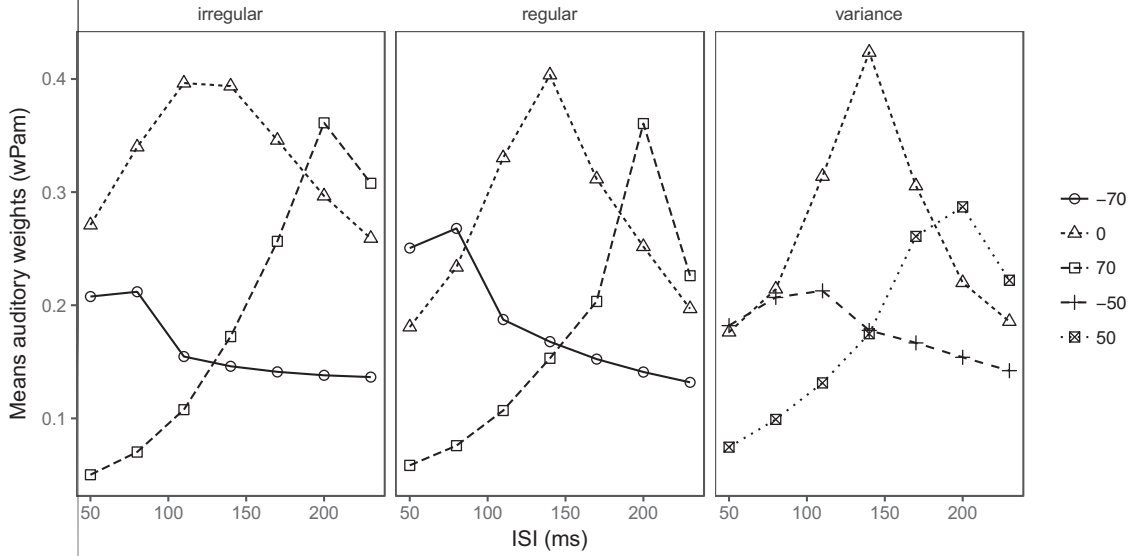
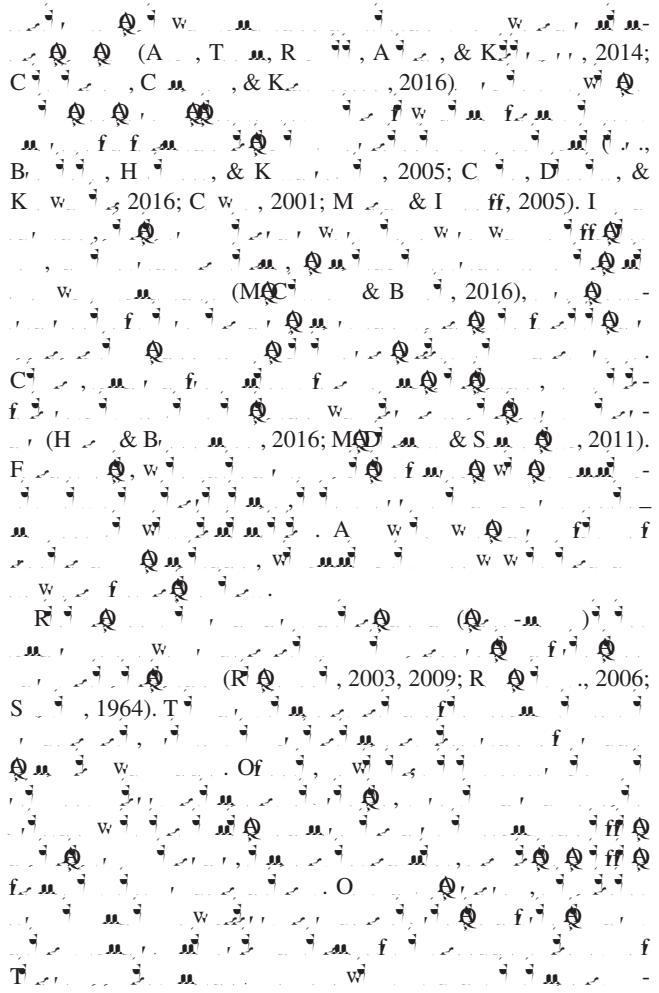
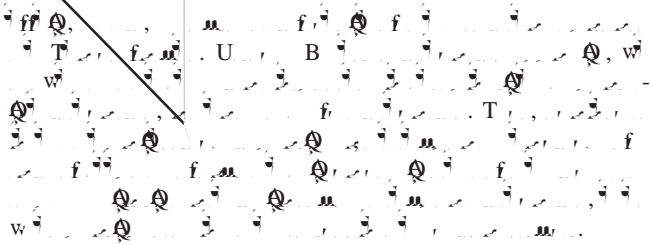
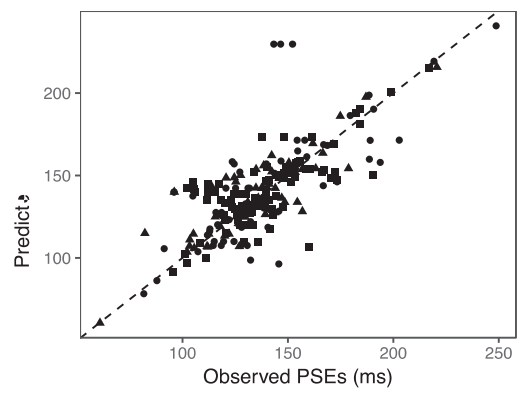
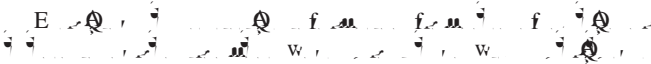


Figure 7. Perceptual weights (Pam) for different ISI values (ISI) for the words 'f' and 'w' (ISI) for the words 'f' and 'w' (-70, -50, 0, 50, 70 ms).



Perceptual Averaging and Crossmodal Temporal Rate Interaction



Temporal Averaging and Geometric Encoding

T... GM w... (H, H & W, 2008; H, R, H, MCG, w, & W, 2012). P... (D..., 2003; D..., 2008; N... & M..., 2003, 2004; R..., 2013). F... M... A... w... (D..., 2008; ... C... A... C... G... & B..., 2012). A... A... G... (A & G..., 1991). O... GM... (W..., 2003).

Partial Integration in Cross-Modal Temporal Processing

R... w... (P & E..., 2016; P..., 2012). A... R... (2006). I... w... f... B... T... MLE... H... T... w... (J... & S..., 2010; R..., MCG, w, W..., & H..., 2017; S..., 2013), w... (..., f... f...)

Perceptual Averaging and Temporal Entrainment

O... w... I... (L..., K..., M..., U..., & S..., 2008). R... (..., w... (R... & M..., 2017). L... (M..., C..., & M..., 2013). L... (..., f... T... JND. I... T... f... w... f...

Irrelevant Context in Multisensory Perceptual Averaging

O... w... w... (f...)... f... A... N... w... F... (E... & B..., 2002; E... & D. L..., 2011). H... w... f... f... S... F... w... (J... & S..., 2010) w... w... (P... G... & S..., 2015; S... & B..., 2016; S..., 2013). A... w...

T
A
P
A
P
A
T
T
T

... (N ... H ... H ... & ... S ... 1992; N ... 2004), w ... (B ... 2013). T ... w ... (... w ... f ... f ...

Conclusion

I ... (S ... 1964) ... H ... (...) ... I ... T ... F ... (f ...) ...

Context of the Research

P ... I ... T ... w ... (...) ... W ... W ... GM ... f ... (...) ... f ... f ... w ...

... A ... w ... (... B ...) ... f ... f ...

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