Acoustic confusability values for 1172 CCC trigrams[1]

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Mean probabilities of acoustic confusability were computed for 1172 CCC trigrams chosen at random from Witmer's list of association values, and the results were tabulated.

Acoustic confusability has been shown to be a strong factor in the recall of letter sequences (Conrad, 1964; Wickelgren, 1965) but it is a variable that is rarely controlled in experiments using CCCs. This is presumably due to the lack of a table of such values and the inconvenience of computing the appropriate values for all CCCs used in such studies.

Conrad (1964) presents an acoustic confusion matrix from which it is possible to compute the mean probability of acoustic confusability of any sequence of letters using Clarke's (1957) Constant Ratio rule.

Mean probabilities of acoustic confusability [p(AC)] were computed for 1172 CCCs chosen at random from Witmer's (1935) list of three-consonant syllables. Because of the difference in British and American pronunciations of the letter "z" ("zed" and "zee") all syllables containing this letter were eliminated. The following table presents the 1172 syllables arranged first by Witmer's association values (AV) and, within each AV, by ascending order of p(AC).

Table 1
CCCs and p(AC) Values, Ranked by Association Value

0%AV	
QJF	.02
XJQ	.02
QJH	.04
XFQ	.21
4%AV	
XQL	.01
KXB	.02
QXJ	.02
DJX	.03
QHJ	.04
FHJ	.07
CXJ	.09
GXM	.09
XQH	.09
XBQ	.10
KHX	.11
HFC	.15
XQF	.21
GCT	.24
8%AV	
FQW	.01
JFQ	.02
MHW	.03
QST	.05
MJF	.06
QLJ	.06
WFC	.07
KQB	.12
DJQ	.16
GXC	.20
XGC	.20
FXQ	.21
QGX	.21
GQ	.21
JXF	.22
Q[illegible]F	.25
QFC	.25
CJQ	.27
CQH	.28
DJB	.34
13%AV	
TFJ	.03
XBN	.03
QJS	.05
QHF	.06
WCF	.07
QXH	.09
XJC	.09
QDJ	.16
QMW	.21
QXF	.21
XFP	.22
XGP	.24
WCQ	.25
QFC	.48
17%AV	
XQM	.01
XQN	.02
JHW	.03
KWQ	.03
KXR	.03
MBX	.03
XBM	.03
XJP	.03
FPJ	.04
HBM	.04
JDF	.04
NQS	.04
QFK	.04
BFM	.05
BMF	.05
DJH	.06
JFM	.06
KHQ	.06
MBW	.06
RBM	.06
XGJ	.06
XJL	.06
HJF	.07
XNJ	.07
WCJ	.08
HXJ	.09
JXH	.09
QHX	.09
SJH	.12
BJQ	.13
QWB	.13
QDJ	.16
PXB	.17
JTQ	.18
NPB	.20
QXG	.21
XFM	.23
XJS	.23
FJS	.32
SXH	.32
DWB	.33
21%AV	
QFW	.01
WFQ	.01
RJW	.02
WJQ	.02
XRJ	.02
HWQ	.03
QHW	.03
WPJ	.03
XQK	.03
BFJ	.04
FJP	.04
TLF	.04
FPN	.05
NLQ	.05
HWF	.06
LJW	.06
WBM	.06
GJW	.07
HJL	.07
WGJ	.07
NQJ	.08
QMK	.08
XMG	.08
JHX	.09
BFQ	.11
DHX	.11
BQH	.12
KBQ	.12
MBQ	.12
FCM	.13
KHC	.15
MCJ	.15
QDM	.15
CSJ	.16
QDH	.16
XCG	.20
FBX	.22
TJB	.22
GQN	.24
KXF	.24
CFX	.27
JQC	.27
SFJ	.32
CFP	.33
KFS	.34
PCJ	.34
TCF	.34
QGD	.43
25%AV	
DLX	.02
HNQ	.02
JFW	.02
KGX	.02
KXP	.03
QLH	.03
RJF	.03
XLG	.03
XMB	.03
SGW	.04
LDH	.05
WJM	.05
FHQ	.06
HKQ	.06
TJL	.06
WFH	.06
XJG	.06
BJW	.07
JWB	.07
RMF	.07
BXH	.09
FHK	.10
HJN	.10
NFJ	.10
QBX	.10
XHN	.10
LJC	.11
MKR	.11
XHK	.11
MWC	.12
NDJ	.12
GKM	.13
JBQ	.13
QBW	.13
RJL	.13
SDH	.13
NCW	.14
CMJ	.15
DKQ	.15
HMC	.15
QDN	.16
PBF	.18
HCX	.19
QSX	.21
BFX	.22
GWQ	.22
JTB	.22
QGL	.22
FHX	.23
QJG	.24
QCW	.25
GXB	.27
QCS	.27
QCH	.28
BJG	.29
GNB	.29
GWB	.29
JBG	.29
QSF	.29
CXS	.32
KDB	.32
XCS	.32
KSF	.34
TFP	.34
GBQ	.40
XSF	.52
29%AV	
LXP	.01
XLQ	.01
BXK	.02
KBX	.02
QNW	.02
RXT	.02
HWJ	.03
JXD	.03
PJW	.03
RHJ	.03
WJP	.03
BJF	.04
FJB	.04
PFJ	.04
QKF	.04
WFM	.04
WSJ	.04
FKB	.05
FWB	.05
HTJ	.05
JMH	.05
JSQ	.05
JTH	.05
NFP	.05
NQH	.05
NXL	.05
SJB	.05
WHB	.05
FDK	.06
HBN	.06
JLQ	.06
JLX	.06
JMF	.06
JXG	.06
KDF	.06
KWB	.06
QHK	.06
RWC	.06
TKF	.06
HKF	.07
XKM	.07
FMH	.08
JQN	.08
LBJ	.08
LRH	.08
WJC	.08
BHX	.09
HNF	.09
RLB	.09
HXN	.10
JNF	.10
MKF	.10
XKN	.10
GJL	.11
KQN	.11
LJG	.11
CFM	.13
DQF	.13
FQD	.13
QFD	.13
XDQ	.13
MGJ	.14
CKH	.15
KQD	.15
KTQ	.18
BPN	.20
CXG	.20
TWB	.20
QLG	.22
DXP	.23
NXF	.23
QMG	.23
KXS	.24
CQW	.25
SGB	.26
CKQ	.27
CNQ	.27
GPN	.27
HCQ	.28
XGD	.28
FSQ	.29
WBG	.29
LDB	.31
TFC	.34
HFS	.38
33%AV	
QWS	.01
RPW	.01
WQS	.01
RXJ	.02
TXJ	.02
WFJ	.02
FQL	.03
KTW	.03
MFQ	.03
MQH	.03
RKB	.03
WQK	.03
BMH	.04
JFD	.04
LBF	.04
MWP	.04
LFN	.05
HJM	.05
HWN	.05
JMW	.05
KSQ	.05
MJT	.05
NQL	.05
PMF	.05
TMF	.05
HFW	.06
JTL	.06
BJM	.07
DWJ	.07
HLJ	.07
JXN	.07
KXM	.07
NWB	.07
DKH	.08
JLB	.08
KHD	.08
KMW	.08
LNF	.08
NJW	.08
XRL	.08
LRB	.09
LXH	.09
XDH	.09
CKF	.10
JNB	.10
XPB	.10
GXN	.11
LHC	.11
QFB	.11
XHD	.11
CSW	.12
HCW	.12
NLR	.12
NRL	.12
WHC	.12
DFQ	.13
FDQ	.13
JRL	.13
QXD	.13
WCN	.14
CJM	.15
NDQ	.16
NQD	.16
QJD	.16
RBP	.17
LPB	.18
TFB	.20
TNB	.21
DFX	.23
DXF	.23
GKT	.23
JGT	.23
MQG	.23
TDF	.23
TJG	.23
JCG	.24
SGP	.24
TDJ	.24
XGB	.26
CSQ	.27
GDW	.30
DLB	.31
BDH	.32
SMF	.32
CNP	.34
FKS	.34
DBQ	.42
PGB	.46
GTD	.49
38%AV	

HWR .01
HWP .02
JWR .02
LBX .02
NWQ .02
TWJ .02
FJT .03
HLB .03
HLW .03
HMW .03
KWR .03
RTF .03
XKT .03
XNR .03
XTK .03
FWM .04
JMX .04
JXM .04
KBS .04
KSW .04
LFB .04
LSW .04
WSM .04
JTM .05
KHR .05
MJQ .05
MPF .05
LWC .06
NLB .06
RCW .06
WMB .06
WNL .06
GWJ .07
JPM .07
LSG .07
PJM .07
CRJ .08
HFN .08
RLP .08
WDM .08
XHR .08
NPJ .09
WLR .09
HNJ .10
MFK .10
JCL .11
BHQ .12
BQW .13
FMC .13
NWC .14
SDQ .14
QKD .15
JCS .16
JDQ .16
QWD .16
NGJ .18
THL .18
TQK .18
GSX .22
GXS .22
PFX .22
SXG .22
XGS .22
FDB .23
FDX .23
GTK .23
QGM .23
XFN .23
PWG .24
SXK .24
TGM .24
CQL .25
PJD .25
DPK .26
QCX .26
XBG .26
CGM .27
CMQ .27
SFQ .29
BSF .30
GJD .31
NSF .31
BDK .32
DFS .32
DSF .32
SFL .32
CPW .33
CJT .34
PJT .35
BTQ .37
HSF .38
SFC .40
GQD .43

42%AV

PWF .02
RFB .02
HQW .03
NBX .03
PXN .03
RJH .03
WKQ .03
DJR .04
RJD .04
RNB .04
WPM .04
FBN .05
FMB .05
FNW .05
HQN .05
JMQ .05
KFB .05
LPN .05
NRH .05
PWK .05
RXG .05
TMJ .05
XRG .05
CFR .06
CWR .06
JLW .06
LCW .06
WCR .06
DSJ .07
JDM .07
JLD .07
SDK .07
XRC .07
DWM .08
HKD .08
WJN .08
XGM .08
BMK .09
GJR .09
MHK .09
NFH .09
NSL .09
RJG .09
TJN .09
NXK .10
XNK .10
LRC .11
MKP .11
NJS .11
NWK .11
QKN .11
CMW .12
KGM .13
KNS .13
NKP .13
NSK .13
DNQ .16
SJC .16
QJT .18
QKT .18
CSN .19
KNG .19
TLB .19
BTW .20
GTX .21
XSQ .21
LDT .22
LGQ .22
XNS .22
DPF .23
DSX .23
FPD .23
GJT .23
GMQ .23
LFX .23
XSM .23
PGX .24
QNG .24
QWC .25
JPG .26
DLG .28
BGW .29
GBN .29
NBG .29
SDG .29
DFB .31
DSB .31
FBD .31
BHD .32
SDF .32
SXC .32
DBN .33
TCW .33
HCT .34
JBD .34
TMC .34
MCP .35
CKP .36
BTG .46
PBG .46
BDP .48
DTG .49
TCG .54
TCP .65

45%AV

LPX .01
RFW .02
RHP .02
RPF .02
JHR .03
NWP .03
PRJ .03
QWH .03
RWK .03
TLW .03
TWM .03
WLH .03
WTF .03
GWS .04
LSQ .04
LWF .04
SKB .04
MHR .05
PFN .05
RPK .05
RWM .05
RXM .05
SQJ .05
THJ .05
WPK .05
BMR .06
BNF .06
HQK .06
NLW .06
WLN .06
JMD .07
JWG .07
KWM .08
MKQ .08
MWD .08
NRJ .09
PNJ .09
JNH .10
NXH .10
KPM .11
PMK .11
QBS .11
RKM .11
SJN .11
RLN .12
FKN .13
HKN .13
HSD .13
NLG .14
FCN .16
LCN .16
QND .16
WQD .16
PBX .17
RBP .17
PSB .18
JPB .21
NBT .21
TLG .21
DXT .22
XDT .22
XFT .22
FDT .23
KGT .23
MXS .23
DPM .25
BGX .26
GPK .27
GDX .28
BWG .29
DKG .29
GBW .29
DGJ .31
DKB .32
FSD .32
LTC .32
XSH .32
CTW .33
CXT .33
PFC .33
TWC .33
WPC .33
TCM .34
KCP .36
QTG .42
DPB .48
BTD .50
BPT .53
TGC .54
GPC .56

50%AV

BKX .02
JXT .02
XJR .02
XMT .02
FTJ .03
GLX .03
JPR .03
KBR .03
PMX .03
WHQ .03
DFL .04
WLH .04
RDK .04
RNW .04
WSN .04
KPR .05
BWM .06
LSD .06
XND .06
HPK .07
DWK .08
MSJ .08
NFD .08
CKW .09
JGR .09
MWG .09
RNJ .09
NBJ .10
CLJ .11
HCR .11
KMS .11
MKS .11
RCL .11
CWS .12
HNS .12
NKD .12
NJD .12
NRK .12
QNB .12
RKN .12
SWC .12
LJR .13
DQM .15
HQD .16
KCS .16
KSC .16
WQT .16
MCS .17
HNC .19
TBX .19
XTB .19
BTF .20
GLC .20
BPK .21
FQX .21
HBT .21
PDR .22
TBJ .22
DWP .23
PDF .23
SXD .23
WDT .23
GXP .24
KTD .24
QCW .25
CMG .27
GBK .27
QSC .27
SQC .27
BGJ .29
FWS .29
KDG .29
SGD .29
BFS .30
LBD .31
CTL .32
FDS .32
LFS .32
PCR .32
CTX .33
PSC .33
PCN .34
TPJ .35
DQB .42
GPD .50
SFX .52
GTC .54
GBP .59

54%AV

XBR .01
FWR .02
MTX .02
RXD .02
WLP .02
WQN .02
FLQ .03
HTR .03
TKX .03
WKT .03
XHT .03
BSW .04
BWS .04
DKR .04
LFW .04
RWN .04
FBK .05
FMP .05
GWL .05
HMR .05
NSB .05
QKS .05
RNH .05
TMR .05
DLS .06
FKR .06
LCX .06
RKF .06
LDW .07
NBW .07
FDN .08
LXR .08
MJS .08
PLR .08
BHS .09
DMK .09
LRW .09
JLS .10
KRM .11
KSM .11
NSJ .11
JND .12
MXC .12
SNH .12
JGM .14
LQT .16
TXQ .16
FTQ .17
QFT .17
NJG .18
HCN .19
TBW .20
BTK .21
CKG .21
XSP .21
FXN .23
JXS .23
KNC .23
PDX .23
SHC .23
GPS .24
NTD .24
SCG .24
RBG .26
GBL .27
MGC .27
PFS .29
CPL .32
DNB .33
LPT .33
JTC .34
KPC .36
DQT .40
GBT .46
PGC .56
DTP .58
CTP .65

58%AV

RWT .01
WPR .01
JRW .02
JWT .02
PRH .02
TXR .02
HQM .03
JRT .03
KRB .03
KRX .03
NTX .03
TRF .03
WTM .03
BPL .04
HTM .04
LBS .04
NRT .04
RHD .04
SBL .04
LXW .05
MFT .05
MPH .05
NBF .05
RHN .05
RTM .05
BNH .06
DSM .06
NFR .06
DNR .07
FLH .07
MKX .07
HFD .08
RDL .09
WMG .09
SQH .10
XTH .10
MGS .11
SGM .11
MRC .13
RCN .14
QMD .15
BPL .18
HTQ .19
NHC .19
TXB .19
PKB .21
TMB .21
XPS .21
CHG .23
FXD .23
PDS .23
PTD .23
LQC .25
MPG .27
HQT .19
RBT .19
TRD .22
DTH .24
BNG .29
BDR .31
SNF .31
CRP .32
DNG .32
PRT .33
NGP .27
DGL .28
GDL .28
CGN .30
GMD .30
RDB .31
MSF .32
SLF .32
TCL .32
PTX .33
FPT .34
HPC .34
NCT .34
THC .34
TKC .34
PTK .36

63%AV

WPS .01
XPL .01
BFR .02
KWT .03
JDR .04

(Continued on page 192)

failure to obtain a reinforcement effect following the first in a series of CS+ trials seems to be a pervasive characteristic of differential eyelid conditioning. The problem these data pose is that an unmodified linear-operator model of differential conditioning (e.g., Bush & Mosteller, 1951) is unable to account for it. The CS+ effect is particularly puzzling in view of the fact that in this study, as well as in that of Prokasy et al, the anticipated decremental effect of a nonreinforced trial was obtained.

If an excitation-inhibition theory of differential conditioning (Spence, 1936) is to account for the data, then it would be predicted that response probability to CS+ in Group C would be less than that in Groups L and R combined. This would be expected because the mean distance of the nonreinforced stimuli from CS+ is less in Group C than in either of the other two Groups. As Fig. 1 suggests, responding to CS+ did not differ reliable between Group C and Groups L and R, $F(1,47) = .03$. While we cannot accept the null hypothesis, the facts that the spatial gradient has been shown to be a relevant dimension and that sequential effects were manifested to the CS– stimuli show that transfer effects do exist. The transfer effect from CS– to CS+ was apparently limited and not a function of spatial separation.

Both the linear operator model of Bush & Mosteller (1951) and the Spence theory of differential conditioning (1936) have in common a prediction that in differential conditioning response probability will increase following a CS+ trial and decrease following a CS– trial. Similarly, the incremental and decremental effects should vary inversely as a function of stimulus discriminability. The failure to find an incremental effect following the first in a sequence of CS+s and the failure for physical separation of stimuli to have a differential effect on responding to CS+ despite a demonstrated discrimination gradient indicates that additional assumptions will be necessary to account for the fine-grain detail of differential classical eyelid conditioning.

REFERENCES

BUSH, R. R., & MOSTELLER, F. A model for stimulus generalization and discrimination. Psychological Review, 1951, 58, 413-423.

PROKASY, W. F., CARLTON, R. A., & HIGGINS, J. D. Effects of nonrandom intermittent reinforcement schedules in human eyelid conditioning. Journal of Experimental Psychology, 1967, 74, 282-288.

PROKASY, W. F., HIGGINS, J. D., & CARLTON, R. A. Sequential effects in differential human eyelid conditioning. Psychonomic Science, 1968, 12, 5.

SPENCE, K. W. The nature of discrimination learning in animals. Psychological Review, 1936, 43, 427-449.

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KRT .04
LTF .04
RKT .04
HPN .05
LTN .05
NLT .05
TFN .05
WGR .05
JLP .06
KRG .06
PMR .06
TNH .06
FLC .07
SWD .07
JMS .08
RLX .08
BLR .09
MKD .09
NDS .09
NHF .09
RBL .09
DNH .10
HSM .10
BSQ .11
BNQ .12
CMR .13
KNP .13
PKN .13
SHD .13
NCR .14
SQD .14
TNQ .17
QTH .19
PMB .20
CGR .21
RDT .22
XSK .23
PGL .24
MDP .25
DGX .28
GDR .28
BRD .31
FSN .31
CLT .32
CPR .32
GDN .32
LPC .32
SCX .33
TRC .33
CNT .34
CTH .34
PTN .34
BPD .48
PDG .50
GCT .54
PDT .58

67%AV

TWR .01
HDR .04
MWS .04
TFL .04
BMS .05
PHN .05
DWR .06
KPS .06
LDS .06
MDH .06
MPR .06
WDR .06
DWS .07
RPL .08
DNS .09
RKC .09
SNL .09
WHS .09
WRL .09
LGR .13
PBL .18
CSH .23
HSC .23
MSX .23
XPD .23
PGN .27
DGN .32
FMS .32
SCP .33
CFT .34
TPF .34
PMT .35
PTG .59

71%AV

BRX .01
FDR .03
RTH .03
JRD .04
NTR .04
PFL .04
BSN .05
HRK .05
FRC .06
FRK .06
KGR .06
KSP .06
MDR .06
RWD .06
CRX .07
FNL .08
TRL .08
HQS .10
QSH .10
HLS .11
JGL .11
KMP .11
WKN .11
WCH .12
HDS .13
KNF .13
MRG .13
SLC .14
NCL .16
NSC .19
TBL .19
TBR .19
FTB .20
CGS .24
SPG .24
GLB .27
DGR .28
LGD .28
BGN .29
DMB .32
NDG .32
WPT .33
PKC .36

75%AV

PRX .01
BKS .04
BSK .04
WMS .04
BRM .06
HTN .06
KFT .06
MRD .06
NBL .06
FLN .08
DRL .09
HPS .09
LND .09
SHW .09
THX .10
CLR .11
RCH .11
TKN .12
WGN .12
HKS .13
GLN .14
BMP .20
RTD .22
TWG .22
GLP .24
PKD .26
MDG .30
FLS .32
PWT .33
TCH .34
CMP .35
MPT .35
PTH .35
SHF .38

79%AV

PWR .01
MXT .02
XTR .02
WHT .03
WTH .03
BWR .04
FWL .04
LPS .04
SWK .04
BNS .05
LNX .05
MRX .05
NBS .05
PMS .05
GRK .06
NTH .06
PKS .06
RPM .06
DKS .07
WDS .07
CRL .11
SQB .11
GWN .12
HNK .13

83%AV

BKR .03
HTL .03
PHL .03
RHT .03
MSQ .04
WNS .04
FWN .05
MRW .05
BLW .06
HNT .06
JLT .06
WRD .06
WLD .07
JRN .09
MRK .11
CRM .13
GLR .13
SHK .13
BTH .21
DPR .22
TGR .22
DFT .23
SPD .23
PRC .32
PCK .36

88%AV

PLS .03
SPN .04
SWN .04
FNT .05
GLW .05
HRN .05
SLD .06
SNG .13
MCH .15
BLT .19
BXT .19
PRD .22
THD .24
DRG .28
PNT .34

92%AV

WRP .01
THR .03
MBR .06
SHP .09
WND .10
MSK .11
TNK .12
RNG .13
KNG .19
GRD .28
DBT .50

96%AV

TWN .03
FLP .04
LFT .04
DSH .13
GRN .13
BND .33
FSK .34

100%AV

DRK .04
SWM .04
PNK .13
SNK .13
DNT .24
DPT .58

REFERENCES

CLARKE, F. R. Constant ratio rule for confusion matrices in speech communication. Journal of the Acoustical Society of America, 1957, 29, 715-720.

CONRAD, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84.

WICKELGREN, W. A. Short-term memory for phonemically similar lists. American Journal of Psychology, 1965, 78, 567-574.

WITMER, L. The Association Value of three-place consonant syllables. Journal of Genetic Psychology, 1935, 47, 337-359.

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