

Dcncpeg"cpf"Rtguuwtg"fkuvtkdwwkqp"wpf"gt"vjg"Hqqv"fwtkpi"Uvcpfkpi"cpf"Ycnmkpi  
ykvj"pq"Qtvjqvkeu"Eqo rctgf"vq"Ewuvqo"cpf"qhh"vjg"Ujgnh"Qtvjqvkeu."C"Rknqv"Uvwf{

Jerrold Petrofsky\*, Iman Akef Khowailed, Brittney N Burtnett, Marina R Korkar and Brittany M Kinney

\*Corresponding author: 'U -HUUROG 3HWURIVN\ 3URIHVVRU DQG 'LUHFWRU RI 5HVHDFK 'HSDUWPHQW RI 3K\VL  
7HO ( PDLO MSHWURIVN\#OOX HGX

Rec date: 6HS Acc date: 1RY Pub date: 1RY

Copyright: < 3HWURIVN\ - HW DO 7KLV LV DQ RSHQ DFFHVV DUWLFOH GLVWULEXWHG XQGHU WKH WHUPV  
XVH GLVWULEXWLRQ DQG UHSURGXFWRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU

### Abstract

**Objective:** 3RWHSDMLQO HOLHI IURP IRRW SDLQ FDQ FRPH IURP D VKRH LQVHUW IRRW  
SUHVXUH GLVWULEXWLRQ DQG EDODQFH LQ RII WKH VKHOI IRRW RUWKRWLFV YHU  
RUWKRWLF

**Methods:** 7KH VXEMHFWV ZHUH ERWK PHQ DQG ZRPHQ 7KH DYHUDJH DJH ZDV  
ZHLJKW ZDV " NJ DQG %0, " (DFK SDWLHQW ZDV ILW IRU ERWK RII W  
RUWKRWLFV DQG QHHGHG RUWKRWLFV WR UHGXFH SDLQ 2QFH ILW WKH\ ZHUH HY  
RQ D OHYHO VXUIDFH ZKLOH EHLQJ PRQLWRUHG E\ D 7DFWLOXV 3UHVVXUH ODSLQ  
SUHVXUH SODWIRUP GXULQJ EDODQFH WHVW

**Results:** :LWK WKH VXEMHFWV DFFRPSOLVKLQJ TXLHW VWDQGLQJ WKH DYHUDJH SU  
IURP WKH KLQG IRRW DQG IRUHIRRW WR WKH PLG IRRW ZKHQ ZHDULQJ IRRW LQV  
SUHVXUH ZDV VLJQLILFDQWO\ VKLIWHG IURP WKH IRUHIRRW DQG KLQG IRRW WR  
JUHDWHVW UHGXFWRQ LQ IRUHIRRW SUHVXUH LQ WKH RII WKH VKHOI RUWKRW  
PHDVXULQJ WKH SHDN SUHVXUH RQ WKH IRRW ZKHUH GXULQJ VWDQGLQJ WKH  
KLJKHU ZLWK QR RUWKRWLF WKDQ VHHQ IRU WKH RUWKRWLFV WHVWHG KHUH %D  
ERWK RUWKRWLF JURXS KDG EHWWHU EDODQFH WKDQ WKH QR RUWKRWLF VWXGL  
\$W OHDVW LQ WKLW VPDOO JURXS RI VXEMHFWV RII WKH VKHOI IRRW RUWKRWLFV

**Keywords:** 2UWKRWLFV 3ODQWDU SUHVXUH \$UFKHV

, QWURGXFWLRQ

)RRWSDLUPHQWV DUH D FRPPRQ FRQGLWLRQ DIIHFWLQJ SHRSOH ZKR  
KDYH PDQ\ GLIIHUHQW OHYHOV RI DFWLYLW\ DQG FDQ KDSSHQ DW DQ\ DJH > @  
2EHVLW\ KLJK PXVFOH DFWLYLW\ ROG DJH DQG DUWKULWLV DUH VRPH RI WKH  
OHDGLQJ FRQGLWLRQV FRQWULEXWLQJ WR IRRW SDLQ > @ )RRW SDWKRORJLH  
LQFOXGH IODWWHQHG DUFKHV WRH GHIRUPLWLHV IURP LPSURSHUO\ ILWWHG VKR  
SURQDWHG IHHW DQG LQIODPHG DFKHV DUH RWKHU FRPPRQ GLVRUGHUV > @

2EHVLW\ LV JURZLQJ LQ \$PHULFD DQG DURXQG WKH ZRUOG > @ \$ VWXG\  
FRQGXFWHG RQ DGXOWV VKRZV WKDW ERWKZV K OERWK WV QZR8à€ WV Q0R0 0

RU G\VIXQFWLRQ FRQVLGHULQJ PDQ\ SHRSOH KDYH QDWXUDO KLJK DUFKHV  
IURP ELUWK > @ 7KH GLIIHUHQFH LQ KHLJKW EHWZHHQ WKH IRUHIRRW DQG WKH  
KLQG IRRW LV RIWHQ DVVRFLDWHG ZLWK D WLJKW SODQWDU IDVFLD > @

\$V D UHVXOW RI SHUVLVWHQW SDLQ SHRSOH PD\ FRPSHQVDWH IRU WKH SDLQ  
E\ ZDONLQJ RQ WKH ODWHUDO ERUGHU RI WKH IRRW DQG UHGXFH UH DU IRRW DG  
IRUHIRRW ORDGLQJ E\ VKLIWLQJ WKHLU ZHLJKW EHDULQJ SDWWHUQ > @ 7R  
UHGXFH SDLQ VKRH LQVHUU RUWKRWLFV LV FRPPRQ\ XVHG

(DUO\ IRRW RUWKRWLF GHVLJQV ZHUH PDGH E\ LQQNHSHUV IURP PDWWHG  
DQLPDO KDLU UHWULHYHG IURP EDUQV ZKLFK WRGD\ ZH NQRZ DV IHOW %XW WK  
IXQFWLRQDO IRRW RUWKRWLF ERRP EHJDQ LQ WKH ODWH dV ZKHQ LQFUHDVHG  
NQRZOHGJH LQ SDWKRORJ\ DQG DQDWRP\ KHOSHG LPSURYH WKH HIIHFWLYHQHV  
RI IRRW RUWKRWLFV > @ 7KHVH QHZ IXQFWLRQDO IRRW RUWKRWLFV HQFRXUDJH

)LJXUHDJUDP RI WKH EDODQFH SODWIRUP

'LDJRQDO PRYHPHQW WRZDUG WKH ULJKW UH DU RI WKH SODWIRUP ZRXOG EH  
PRYHPHQW LQ WKH ILUVW TXDGUDQW PRYHPHQW WR WKH ULJKW IURQW RI WKH  
SODWIRUP WKH VHFRQG TXDGUDQW PRYHPHQW WR WKH OHIW IURQW RI WKH  
SODWIRUP ZRXOG EH WR WKH WKLUG TXDGUDQW DQG PRYHPHQW WR WKH OHIW  
UH DU RI WKH SODWIRUP ZRXOG EH WR WKH IRXUWK TXDGUDQW 0RYHPHQW  
GLUHFWO\ WRZDUG WKH GLUHFW EDFN RI WKH SODWIRUP LV LQ WKH < GLUHFWL  
DQG PRYHPHQW WR WKH ULJKW LV LQ WKH ; GLUHFWLRQ ,I WKH SHUVRQ ZDV  
VWDQGLQJ ZLWK WKHLU FHQWHU RI JUDYLW\ H[DFWO\ DERYH WKH FHQWHU RI W  
SODWIRUP WKH\ ZRXOG EH DW WKH RULJLQ DQG QRW OHDQLQJ WR DQ\ DQJOH ,Q  
IRXU TXDGUDQW V\ VWHP DQJOHV VWDUW DW WKH WRS DQG LQ D FORFNZLVH  
GLUHFWLRQ JR IURP r WR r )RU H[DPSOH OHDQLQJ WRZDUG WKH IURQW RI

ZHUH VROYHG WLP HV SHU VHFRQG IRU D FRQWLQXR XV SUHVHQWDWLRQ RI WKH DQJOH DQG PDJQLWXGH RI WKH YHFWRU DVVRFLDWHG ZLWK DQ\ VZD\ OLQNH WR HLWKHU WUHPRU RU PRYHPHQW LQ WKH ERG\ > @ %\ DYHUDJLQJ WKH YHFWRU PDJQLWXGH RYHU VHFRQGV PHDQ DQG VWDQGDUG GHYLDWLRQ 6' ZHUH REWDLQHG IRU WKLV PHDVXUH 7KH &RHIILFLHQW RI 9DULDWLRQ &9 RI PRYHPHQW ZDV FDOFXODWHG 6PHDVXUH RI WKH SRVWXUDO VZD\ > @ 7KH DYH DJH &9 RI HDFK WDVN ZDV WKHQ GHWHUPLQHG E\ DYHUDJLQJ WKH &9V RI WKH VHSUDWH WULDOV 7KH EDODQFH SODWIRUP ZD YDOLG DWHG LQ SUHYLR XV VWXGLHV > @

%DODQFH WDVNV

(LJKW TXLHW VWDQGLQJ EDODQFH WDVNV HDFK ODVWLQJ IRU VHFRQGV ZHUH LQFOXGHG LQ WKLV VWXG\ > @ 7R FKDOOHQJH WKH VRPDWRVHQVVRU\ LQSXW GLIIHUHQW IRRW SRVLWLRQV IHHW DSDUW DQG WDQGHP DQG GLIIHUHQW VXUI FRPSOLDQFHV ILUP VXUIDFH DQG IRDP ZHUH XVHG 7R FKDOOHQJH WKH YLVXDO LQSXW OHYHOV RI YLVLRQ H\HV RSHQ DQG FORVHG ZHUH XVHG LQ WK EDODQFH WDVNV \$Q \$HURPDWLRQ EDODQFH \$DORFN \*URXS \$HURPDW )LWQHVV 3URGXFW )UHPRQW &\$ ZDV SODFHG RQ WRS RI WKH EDODQFH SODWIRUP DQG ZDV XVHG DV WKH IRDP VXUIDFH 7KH HLJKW EDODQFH WDVNV DUH OLVWHG EHORZ

k 6WDQGLQJ ZLWK IHHW DSDUW RQ D ILUP VXUIDFH ZLWK H\HV RSHQ )\$(2),50 DQG H\HV FORVHG )\$(& ),50

k 6WDQGLQJ ZLWK IHHW LQ WDQGHP RQ D ILUP VXUIDFH ZLWK H\HV RSHQ 7(2 ),50 DQG H\HV FORVHG 7(& ),50

k 6WDQGLQJ ZLWK IHHW DSDUW RQ D IRDP VXUIDFH ZLWK H\HV RSHQ )\$(2)2\$0 DQG H\HV FORVHG )\$(& )2\$0

k 6WDQGLQJ ZLWK IHHW LQ WDQGHP RQ D IRDP VXUIDFH ZLWK H\HV RSHQ 7(2 )2\$0 DQG H\HV FORVHG 7(& )2\$0

3URFHGXUHV

(YDOXDWLRQ DQG FRPSDULVRQ RI FXVWRP DQG RII WKH VKHOI RUWKRWLFV ZDV FRQGXFWHG ZLWK WKH VDPH VKR HV 7KH SDUWLFLSDQWV ZHUH UHTXLUHG WR SURYLGH DQ\ UXQQQLQJ RU ZDONLQJ VKR HV RI WKHLU FKRLFH ZLWK WKH H[FH SWLRQ LI WKH VROH KDV KLJK GDPDJH RU WHDUV (DFK SDUWLFLSDQW ZDONH D GLVWDQFH RI PHWHUV WZR FRQVHFXWLYH WLP HV DW WKHLU QRUPDO SDFH RQ D IODW OLQROHXP VXUIDFH ZLWK QR RUWKRWLFV FXVWRP RU RII WKH VKHOI RUWKRWLFV 7KH 7DFWLOXV 3UHVVXUH ODSSLQJ 6\ VWHP FROOHFWHG DOO JDLW GDWD (DFK VXEMHFW WKHQ VWRRG LQ GLIIHUHQW SRVLWLRQV LQ D UDQGRP RUGHU IRU WHQ VHFRQGV HDFK ZKLOH ZHDULQJ FXVWRP RUWKRWLFV RII WKH VKHOI RUWKRWLFV DQG QR RUWKRWLFV

'DWD DQDO\VLV

'DWD DQDO\VLV LQYROYHG WKH FDOFXODWLRQ RI PHDQV DQG VWDQGDUG GHYLDWLRQV 7R FRPSDUH PHDQV QRQ SDUDPHWULF VWDWLVLWLFV ZHUH XVHG )LUVW GDWD ZDV WHVWHG DQG VKRZQ WR EH D QRUPDO GLVWULEXWLRQ E\ D .ROPRJRURY 6PLUQRY WHVW 1H[W PHDQ FRPSDULVRQV ZHUH PDGH E\ .UXVNDQ :DOOLV QRQ SDUDPHWULF RQH ZD\ \$QRYD 7KH VLJQLILFDQFH ZDV S

5HVXOWV

7KH SUHVXUH PHDVXUHG XQGHU WKH IRRW ZLWK QR LQVHUW LV LOOXVWUDWHG )LJXUH \$ \$V FDQ EH VHHQ KHUH IRU WKH QR RUWKRWLFV FRQGLWLRQ WKH

Citation: 3HWURIVN\ - .KRZDLOHG , \$ %XUWQHWW %1 .RUNDU 05 .LQQH\ %0 %DODQFH  
6WDQGLQJ DQG :DONLQJ ZLWK QR 2UWKRWLFV &RPSDUHG WR &XVWRP DQG RII WKH  
GRL ;

GLIIHUHQW LQ WKH IRUHIRRW WKDQ WKH PLG IRRW DQG KLQG IRRW ZKHQ ZDONLQJ  
S! 7KH SHDN SUHVXUHV DOVR VKRZQ LQ WKLV LIXUH VKRZUQ EXV  
VLJQLILFDQWO\ ORZHU SHDN SUHVXUHV DOVR VKRZUQ LQ WKLV LIXUH VKRZUQ EXV  
ZKHQ ZDONLQJ WKH IRUHIRRW DQG PLG IRRW DQG KLQG IRRW ZKHQ ZDONLQJ  
S! 7KH SHDN SUHVXUHV LQ WKH IRUHIRRW DQG PLG IRRW DQG KLQG IRRW ZKHQ  
WKDQ WKH PLG IRRW DQG KLQG IRRW ZKHQ ZDONLQJ S!  
7KH SUHVXUH PHDVXUH XQGHU WKH IRUHIRRW DQG PLG IRRW DQG KLQG IRRW ZKHQ  
LOOXVUDWHG LQ )LJXUH & \$V FDQ EXW ZKHQ ZDONLQJ S!  
ZKLFK ZDV VLJQLILFDQWO\ ORZHU ZKHQ ZDONLQJ S!  
PLG IRRW DQG KLQG IRRW S ZDV QHUVHUWKH LQ WKH IRUHIRRW DQG PLG IRRW  
IRUH IRRW WKDQ WKH PLG IRRW DQG KLQG IRRW ZKHQ ZDONLQJ S!  
SHDN SUHVXUHV DOVR VKRZQ LQ WKLV LIXUH VKRZUQ LQ WKLV LIXUH VKRZUQ  
WKH IRUHIRRW VWDQGLQJ S EXW ZKHQ ZDONLQJ S!  
IRRW KDG WKH VDPH SHDN SUHVXUHV DOVR VKRZUQ LQ WKLV LIXUH VKRZUQ  
KLQG IRRW ZHUH VLJQLILFDQWO\ OHVV WKDQ WKH PLG IRRW DQG KLQG IRRW ZKHQ  
ZDONLQJ S

&RPSDULVRQ RI WKH IRRW LQVHUW LQ WKH IRUHIRRW DQG KLQG IRRW ZKHQ ZDONLQJ  
&RPSDULQJ GDWD LOOXVUDWHG LQ WKH IRUHIRRW DQG KLQG IRRW ZKHQ ZDONLQJ  
VXEMHFW DFFRPSOLVKLQJ TXLHW VWDQGLQJ RYHUWKH IRUHIRRW DQG KLQG IRRW  
VKLIWHG IURP WKH KLQG IRRW DQG IRRW LQVHUW ZKHQ ZDONLQJ S!  
IRRW LQVHUW ZKHQ VXEMHFW ZHUH VWDQGLQJ LQ WKH IRUHIRRW DQG KLQG IRRW  
RUWKRWLF SUHVXUH ZDV VLJQLILFDQWO\ OHVV WKDQ WKH IRUHIRRW WKDQ WKH R  
VKHOI RUWKRWLF 3 'XULQJ ZDONLQJ WKH DYHUDJH SUHVXUH ZDV  
VLJQLILFDQWO\ VKLIWHG IURP WKH IRUHIRRW DQG KLQG IRRW WR WKH PLG IRRW  
ERWK RUWKRWLF JURXS ZLWK WKH JURXSV IRRW LQVHUW LQ WKH IRUHIRRW SUHV  
LQ WKH RII WKH VKHOI RUWKRWLF JURXS S ZKLV LV HVSHFLDOO\ VHHQ  
ZKHQ PHDVXULQJ WKH SHDN SUHVXUHV WR WKH IRUHIRRW ZKHQ ZDONLQJ S!  
VWDQGLQJ WKH SHDN SUHVXUHV RQ WKH IRUHIRRW ZKHQ ZDONLQJ S!  
RUWKRWLF WKDQ VHHQ IRU WKH RUWKRWLF IRRW LQVHUW ZKHQ ZDONLQJ S!  
IRUHIRRW SHDN SUHVXUHV ZHUH XQFKDQJLQJ LQ WKH IRUHIRRW ZKHQ ZDONLQJ S!  
RUWKRWLF H[SHULPHQW EXW PLG IRRW LQVHUW ZKHQ ZDONLQJ S!  
LQ WKH RUWKRWLF JURXS S

%DODQFH 'DWD  
'DWD LQ WKLV VWXG\ ZDV SORWWHG LQ WKH IRUHIRRW DQG KLQG IRRW ZKHQ ZDONLQJ  
H[SHULPHQW E\ LQFUHDVLQJ RUGHU RQ RUWKRWLF DQG VSHKRVLQJ IRU WKH  
H[DPLQLQJ )LJXUH GDWD ZDV SORWWHG LQ WKH IRUHIRRW DQG KLQG IRRW ZKHQ  
VHQVUR\ FKDOOHQJH RQ WKH ; D[LV WKH IRRW GXULQJ VWDQGLQJ DQG JDLW >

, Q WKLV VWXG\ VZD\ LQFUHDVHG DV WKH DSHUDDYRRGLVFXOWDREGWKHWHWDFDGLQ  
WDVNV LQFUHDVHG )RU HDFK WDVN H[DPLQH WKH SRWHQWDO RFRSGR WKPHQWD  
LQFUHDVHG )RU H[DPSOH ZKHQ FRPSDULW WKH WHWDRYHU WKH PILG VRRW ZLWK  
SRVLWLRQV VWDQGLQJ IHHW DSDUW H[VW 2SHQ KRHH QVHUWR FKQVHG\ VLKH IHHW  
IURP )HHW \$SDUW (\HV 2SHQ WR DOPRVW VLGRLQJ LQ WKH IRUHIRRW DQG KLQG IRRW  
&ORVHG 7KLV LQFUHDVH ZDV VLJQLILFDQWO\ XQGKLEWKHWRZHUHQ DQG LW FD  
FKDOOHQJHG HYHQ IXUWKHU ZKHQ WKH IRRW ZDV DRIWDPXEDGQ ,WKWKSUHQW  
SRVLWLRQV VZD\ ZDV LQFUHDVHG IXUWKHU WKH IRRW ZKHQ ZDONLQJ S!  
WKHUH ZDV QR VWDWLWLFDO GLIIHUHQFH RIRRQ ZHIHQWKHMKHQ IRUWKH VDPHWHW  
DQG FXVWRP RUWKRWLF JURXS S! GLVWULXWLRQ WKH WRDQVBLQLEXORW VKRZ  
SRVLWLRQV WHVWHG IRU EDODQFH VZD\ ZDV VHQVUR\ VDPHWHW VZD\ WKH IRRW  
RUWKRWLF JURXS WKDQ WKH QR RUWKRWLF JURXS S WXG\ )RUWKH PRVW R  
GLIILFXOW SRVLWLRQV WKH FXVWRP RUWKRWLF JURXS VZD\ VDPHWHW VZD\ WKDQ W  
RII WKH VKHOI RUWKRWLFV JURXS S WKH\ UHFHLYHG SDLQ UHOLHI ZKHQ ZHDUL  
DQG RI WKH VXUYHGH UHSRUWHG W IXQFWLRQDO DFWLYLW\ OHYHO DIWHU ZHD  
VXUYH\ VKRZV WKDW FXVWRP RUWKRWLFV SDWKRORJLHV EXW DJDLQ GLG QRW HYDC

LQVHUW ZRXOG EH DEOH WR SURYLGH WKH QV DFRQS DFKH M R K Q L W R R O U F R R Z W E D R O D G R E  
PLJKW EH DOWHUHG

5DWKHU WKDQ H[DPLQH SDLQ LQ WKH SUHVVHQW\ WKH QV DFRQS DFKH M R K Q L W R R O U F R R Z W E D R O D G R E  
SUHVXUH GLVWULEXWLRQ RQ WKH IRRW LQ WKH QV DFRQS DFKH M R K Q L W R R O U F R R Z W E D R O D G R E  
RUWKRWLF FRPSDUHG WR RII WKH VKHOI DQO KFX WWR RDRUW KR WLR FRERN DQ IXQFWLRQD  
VLJQLILFDQFH ZDV WKH DVVHVVPHQW RI EDODQFH\ D O H H P D Q X U L Q J V W S I D Q G I R Q J S W D  
IRRW LQVHUWV VKLIWHG VLJQLILFDQW SUHVF XORVNUH R P W W K H K O R I U H I R R W W R W K H F  
IRRW ZKHQ VWDQGLQJ 7KLV ZDV DOVR W D U G C H V R Q S H D N L Q S U H V V X U H V - Z K H Q L Q O D \  
VWDQGLQJ RU ZDONLQJ 7KLV WKHQ DJUH F X V Z K W R V N H Q W X D Q R Q V F X G H W R P S D Q R I Q G  
WKH VKHOI RUWKRWLFV RQ FDGDYHUV H[DPSOH\ S U V V A Q U H V P D O G L L W U B R O L Q W K  
ERQH V RI WKH IRRW > @

6RPDWRVHQVRU\ LQIRUPDWLRQ IURP WKH EDODQFH\ D O H H P D Q X U L Q J V W S I D Q G I R Q J S W D  
WR EH LPSRUWDQW LQ WKH SRVWXUDO FROOH DJR Q L V D Q G D Q W H U D V L Q J D S U H Y L R \  
VWXG\ VZD\ ZDV ZRUVH LQ WKH PRVW G L O H L D Q G W U B D O Q F H L W D A N V J G H Q @ & / ) R U 3  
VLPSOH EDODQFH WHVWV WKH LQVHUWV D Q G I M W H G G O R Q E W W W R U V W D I C X Q F R Q G R U E L  
EDODQFH WHVWLQJ WKDQ GLG WKH QR LQVHUW W H V W L Q J % X W I R U W K H P R V W G L  
EDODQFH WDVNV ZKHQ YLVLRQ DQG IHHO L D N K R Z L W K H Q H H W & D W R O P P R Y H E W D %  
LQSXWV IURP EDODQFH WKH FXVWRP RUWKR W L F W R D O W K H Q R R U W K R W L F F R O G L V  
EDODQFH WKDQ WKH RII WKH VKHOI RUWKR W L F W R D O W K H Q R R U W K R W L F F R O G L V  
7KHUH KDYH RQO\ EHHQ D IHZ VWXGLHV ) H I & U W K R W L F V D Q G 7 K H H I H F W V R I R E H V  
H[DPSOH ZKHQ XVLQJ DQ \$)2 YV WDSLQJ D Q O H S D W K R O R J V R E W S O N O H G W  
RUWKRVLV KDG EHWWHU EDODQFH > @ D O W H U S O S W B U Z O R D G L Q V D Q G I X Q F W L R Q  
EUDFHV HYHQ RII WKH VKHOI RUWKRWLFV Y U W K R S S R W R P K V 7 K L V D O W H U H G W K H P X  
DFWLYLW\ LQ WKH YDVWXV ODWHUDOLV D Q G L O X W H X V P H G K X Y D G X U L Q J H H H F L V H  
7KLV VDPH W\SH RI LQFUHDVHG PXVFOH I R F W S D L W L G D F R P H H Q W L Q Z I Z O I H R O G H U  
ZHDULQJ KLJK KHOOV ZKHUH IRRW VWDELOLW\ S U V S Z D W L P D E R K R D W Q H X E \ L Q F U H D V H G S  
PXVFOH FR FRQWUDFWLRQ > @ 7KH LQFUHDVHG PXVFOH D F W S D L W L G D F R P H H Q W L Q Z I Z O I H R O G H U  
FRQWUDFWLRQ ZRXOG DLG WR VWLIIHQ W E D I R R D W S Q I V D X N O H D Q G I D R Z H U Q O H G B  
VKRXOG LQFUHDVH SRVWXUDO VWDELOLW\ H W D W W K A R A [ S H Q V H R I L Q F U H D V H G P X V  
DFWLYLW\ :KLOH PDLQWDLQLQJ EDODQFH H L Q R O X Q Q - W K H Q N Q A W H % D Q W L R Q R I H W K  
VHQVRU\ VIVWHPV YHVWLEXODU YLVXDO G L O G G R I P P W R V R R Q L D R V H G V Z V W H P X Q F W L R Q  
&16 WKH PRWRU VIVWHP LV DOVR LPSHUDWLYH LQ SRVWXUDO R E P R O W U R O @ - 7 K  
PXVFXORVNUHODWDO VIVWHP FDQ DGG WR \$ H P E S O I R X E K L X V L Q H D F W Z K D W K L R Q R I H  
DJRQLV DQG DQW DJRQLV DFWLYLW\ WR ) O H V D H G S O D W P D S U H V V X U H / D Q G L W R O  
FROOH DJXHV > @ KDYH VKRZQ D FRUHO O P F R D P E I E D E V F S H P D F W L Y D W A D W E W K H  
DQNOHV ZLWK WKH VKRUW WHUP SRVWXUDO Z V U R S Z R H G D Q G A F E R O D H O B X N V R V @  
DOVR UHSRUWHG DQ DVVRFLDWLRQ RI WKH LQFUHDVH LQ ERG\ VZD\ ZLWK  
ZHDNQHVV DW ORZHU OHJV HVSHFLDOO\ WKH DQNOH GRUVLIOH[RUV > @ 7KLV D  
FDQ EH VDLG RI WKH RUWKRWLF LWVHOI % \ U H G X F L Q J I O H [ L E L O L W \ R I W K H I R R W  
VKLIWLQJ ZHLJKW WR WKH FHQWHU RI WKH IRRW LQ OLQH ZLWK WKH FHQWHU  
JUDYLW\ RI WKH ERG\ LW VKRXOG LQFUHDVH SRVWXUDO VWDELOLW\ 3RVWXU  
VWDELOLW\ ZDV EHWWHU LQ FXVWRP RUWKRWLFV SUREDEO\ GXH WR EHWWHU IL  
VLQFH WKH RII WKH VKHOI RUWKRWLFV DOVR LQFUHDVHG EDODQFH

7KLV VWXG\ ZDV OLPLWHG WR RQH IRRW SDWKRORJL RQ IRXQJHU SHRSOH  
)XUWKHU UHVHDFK QHGV WR ORRN DW RWKHU SDWKRORJLHV DQG V X E M H F W J U H  
WR IXUWKHU H[SORUH WKH GLIIHUHQFHV LQ WKHVH RUWKRWLFV  
) N @ B O E B O L J K W O V E O . 0 P L W K @ & / E a  
D S I Y H n . J L P . 0 p = 0 0 ! . @ B ) R I X Q F W

&RQFOXVLRQ

,Q WKH SUHVVHQW\ LQYHVWLJDWLRQ FXVWRP PDGH VKRH LQVHUWV PDGH D  
VLJQLILFDQW GLIIHUHQFH LQ WKH DPRXQW RI SUHVXUH GLVWULEXWLRQ DQG  
EDODQFH GXULQJ JDLW 7KH VXEMHFW KRZHYHU RQO\ FRQVLVWHG RI SHRSOH  
ZLWK OLWWOH WR QR IRRW SDWKRORJLHV RU SDLQ GXULQJ JDLW 7KHVH VWXG  
VKRXOG EH H[SDQGHG WR ERWK ROGHU VXEMHFW DQG VXEMHFW ZLWK IRRW  
SDWKRORJLHV DQG UHSHDWHG RQ ODUJHU QXPEHUV RI VXEMHFWV

5HIHUHQFHV

\*ROLJKW OADQQDQ 07 'XIRXU \$% +LOOVWURP +- -RUGDQ -0  
)RRW GLVRUGHUV DVVRFLDWHG ZLWK RYHUSURQDWHG DQG RYHUVXSLQDWHG IRRW

3HWURIVN\ -6 \$ GHYLFH IRU WKH HYDOXDWLRQ RI VLWWLQJ DQG UHDFK  
EDODQFH LQ SHRSOH LQ ZKHHOFKDLUV DQG VWDQGLQJ - 0HG (QJ 7HFKQRO

3HWURIVN\ -6 )RFLO 1 3URZVH 0 .LP < %HUN / HW DO \$XWRQRPLF  
VWUHV DQG EDODQFH WKH LPSDFW RI DJH DQG GLDEHWHV 'LDEHWHV 7HFKQRO  
7KHU

3HWURIVN\ -6 /RKPDQ (% UG ODJQHWFDOO\ FRXSOHG EDODQFH  
SODWIRUP - 0HG (QJ 7HFKQRO

7VH< 3HWURIVN\ - 0LFKDHO / 3DXOD & 1RKD ' HW DO 3RVWXUDO  
VZD\ DQG (0\* DQDO\VLV RI KLS DQG DQNOH PXVFOHV GXULQJ HLJKW EDODQFH  
WUDLQLQJ WDVNV ,QWHUQDWLRQDO -RXUQDO RI 7KHU\S\ DQG 5HKDELQDWLRQ

7VH< 3HWURIVN\ -6 %HUN / 'DKHU 1 /RKPDQ ( HW DO 3RVWXUDO  
VZD\ DQG UK\WKPLF HOHFWURHQFHSKDJUDSK\ DQDO\VLV RI FRUWLFDO DFWLYDWLRQ  
GXULQJ HLJKW EDODQFH WUDLQLQJ WDVNV 0HG 6FL 0RQLW

'RQDW\$G&XUOEXUW & &RQDZD\ ' 6W 3LHUUH 5 %LRPHFKDQLFDO  
IRRW RUWKRWLFV D UHWURVSHFWLYH VWXG\ - 2UWKRS 6SRUWV 3K\ 7KHU

\$QDFHU'L )DELR 53 ,QIOXHQFH RI VHQRU\ LQSXWV RQ VWDQGLQJ  
EDODQFH LQ FRPPXQLW\ GZHOOLQJ HOGHUV ZLWK D UHFHQW KLVWRU\ RI IDOOLQJ  
3K\ 7KHU

+RUD% 1DVKQHU /0 'LHQHU +& 3RVWXUDO VWUDWHJLHV DVVRFLDWHG  
ZLWK VRPDWRVHQVRU\ DQG YHVWLEXODU ORVV ([S %UDLQ 5HV

.HQQHG\ 30 ,QJOLV -7 'LVWULEXWLRQ DQG EHKDYLRXU RI JOEURXV  
0°À`€DSX VH HW Iñ9 'pm€` @